OPERATIONS MANUAL FOR POWER SUPPLY/MODULATOR

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Submitted to:

Philips Elektronikindustrier AB
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Submitted by:

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SECTION 1
INTRODUCTION

Under Purchase Order D21-247145, the Georgia Institute of Technology/ Engineering Experiment Station (GIT/EES) of Atlanta, Georgia (USA), developed a radar modulator/high voltage power supply for the Philips Elektronikindustrier AB of Jarfalla, Sweden. The modulator/power supply was originally built for integration with Philips 9LV200MK2 series of radars and is intented for use with a Varian Canada Bridded Extended Interaction Oscillator (EIO). This manual describes the maintenance and operation of the modulator/power supply assembly and also includes an engineering discussion on its theory of operation. Appendices are included that contain schematics, parts location drawings, parts lists, and manufacturers' data sheets for selected parts.

*** DANGER - HIGH VOLTAGE - USE EXTREME CAUTION ***

Figure 1 is a block diagram of the modulator/power supply assembly. Caution must be taken at all times when working near the modulator/power supply assembly due to the presence of high voltage. A TTL circuit receives the synchronization signal and generates three pulses that are optically coupled to the floating-deck modulator. Optical coupling is used to isolate the low-level digital circuitry from the modulator deck which floats at about -21 kV. These three optically-coupled pulses define the length of the high voltage pulse. The control and protection circuits are solid state circuits that control and monitor the status of the modulator. The formation of the optically-coupled pulses and the high-voltage pulse, the operation of the control and protection circuits, and the low-voltage and high-voltage power supplies are discussed in more detail in Section 3.

The modulator accepts an input synchronization signal and generates a high voltage pulse relative to each rising edge of the synchronization signal. Therefore, the pulse repetition frequency (PRF) of the synchronization

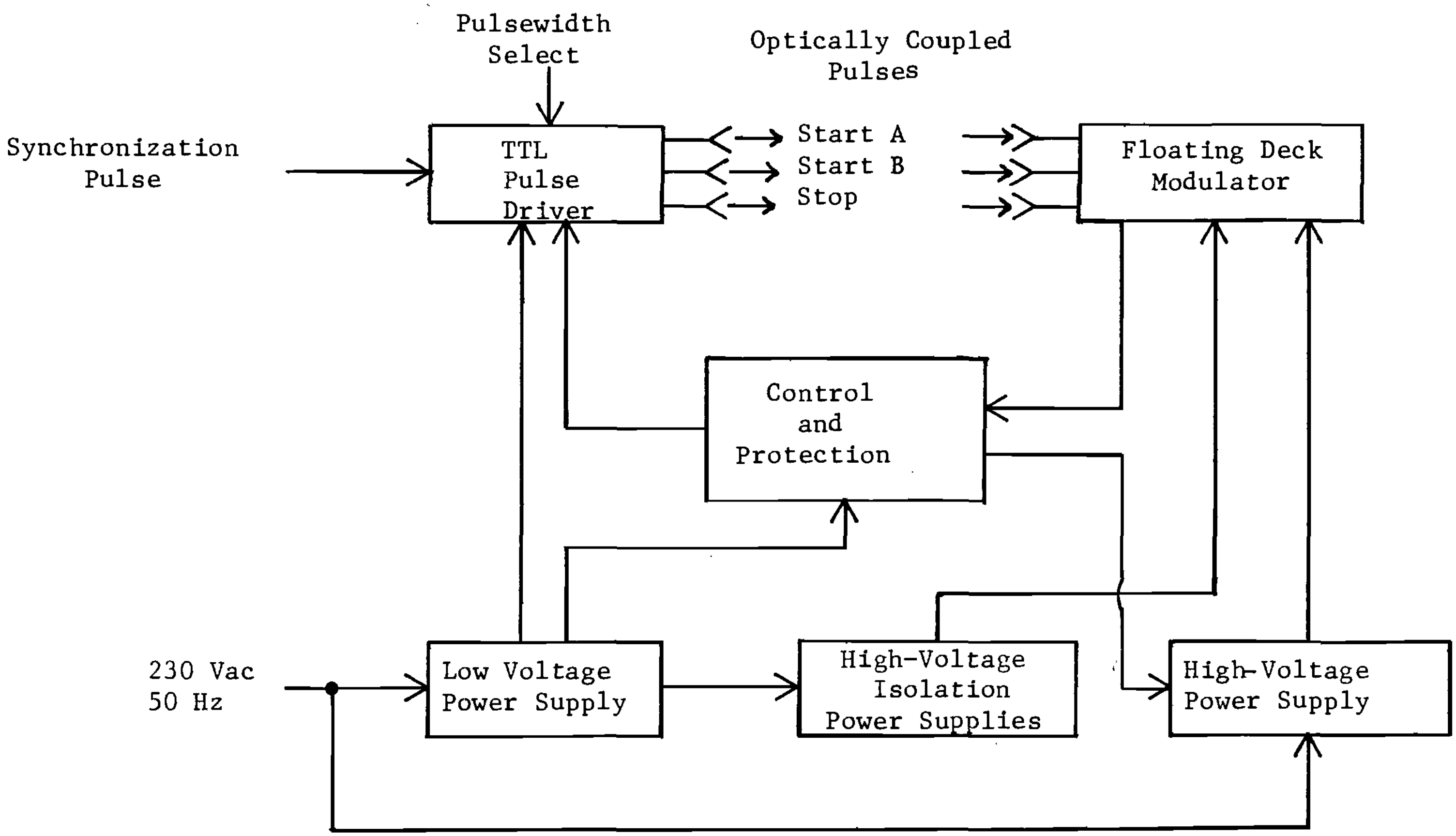


Figure 1. Block diagram of modulator/power supply assembly.

signal equals that of the high voltage pulse train. The necessary characteristics of the synchronization signal and the characteristics and power requirements of the modulator/power supply assembly are listed in Table 1.

TABLE 1. MODULATOR/POWER SUPPLY SPECIFICATIONS

Input Synchronization Signal:		
	Amplitude	+6 ± 2 V
	Pulse Length	0.7 ± 0.3 μs
	Rise Time	< 100 ns
	Load Impedance	50-75 ohm
	Pulse Repetition Frequency	1-20 kHz
Pulse Width		35-200 ns
Power Requirements		230 VAC, 50 Hz
Size	Modulator	42 cm x 15.6 cm x 25.4 cm
	Power Supply	41.3 cm x 13.3 cm x 43.2 cm
Weight	Modulator	14.5 kg
	Power Supply	20 kg

SECTION 2
MAINTENANCE AND OPERATION

2.1 INTRODUCTION

This section discusses the maintenance and operation procedures necessary for safe and proper utilization of the modulator/power supply. This discussion can be used to train operators how to USE the assembly; however, only qualified engineering personnel should be allowed to disassemble or modify the modulator or power supply. A detailed discussion of the theory of operation of the assembly is included in Section 3 to aid engineering personnel and should be referenced before performing maintenance or making modifications.

2.2 MAINTENANCE AND SETUP PROCEDURE

The modulator/power supply assembly consists of the following items: modulator enclosure, power supply enclosure with front panel, multiconductor cable, coaxial cable, and high-voltage cable. To set up the system for operation, all three cables must be connected between the two enclosures, the AC line cord from the power supply enclosure must be connected to a grounded 230 VAC outlet, and the high voltage power supply must be connected to a good chassis ground.

Figure 2 is an illustration of the modulator enclosure. The left side plate must be removed to service the interior of the enclosure. Figure 3 is a view of the interior of the modulator asembly with the side plate removed and shows the location of various major components and circuits. The exposed plexiglass plate must be removed to work on the floating deck modulator. Because of the high voltage, care must be taken when working inside the modulator enclosure; **THE INTERIOR OF THE PLEXIGLASS MODULATOR ENCLOSURE FLOATS AT THE BEAM POTENTIAL (-21 kV).** The bottom of the enclosure is surrounded by potting material. If any of this material is cut away it must be replaced before application of high voltage to the modulator. The bottom

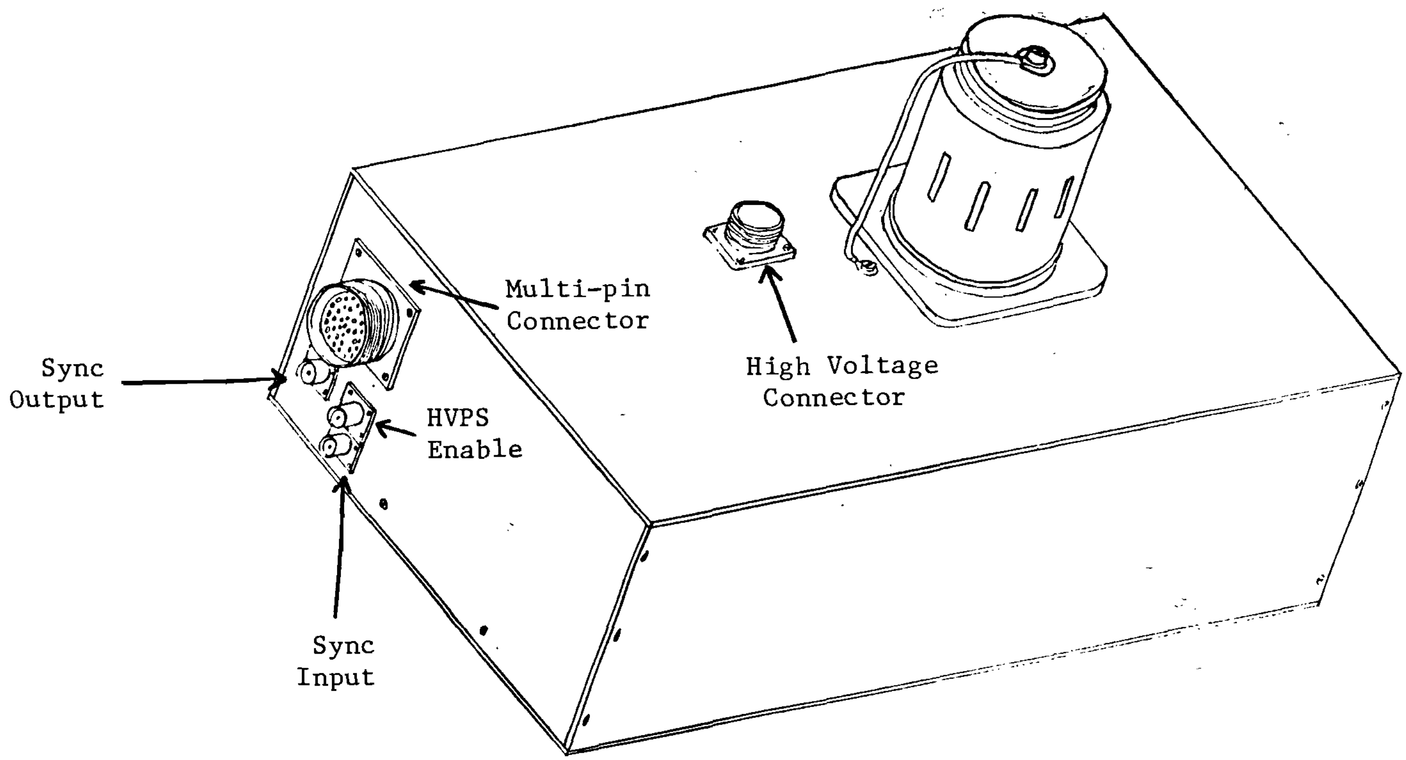


Figure 2. Modulator enclosure.

(Left side plate is underneath in this view)

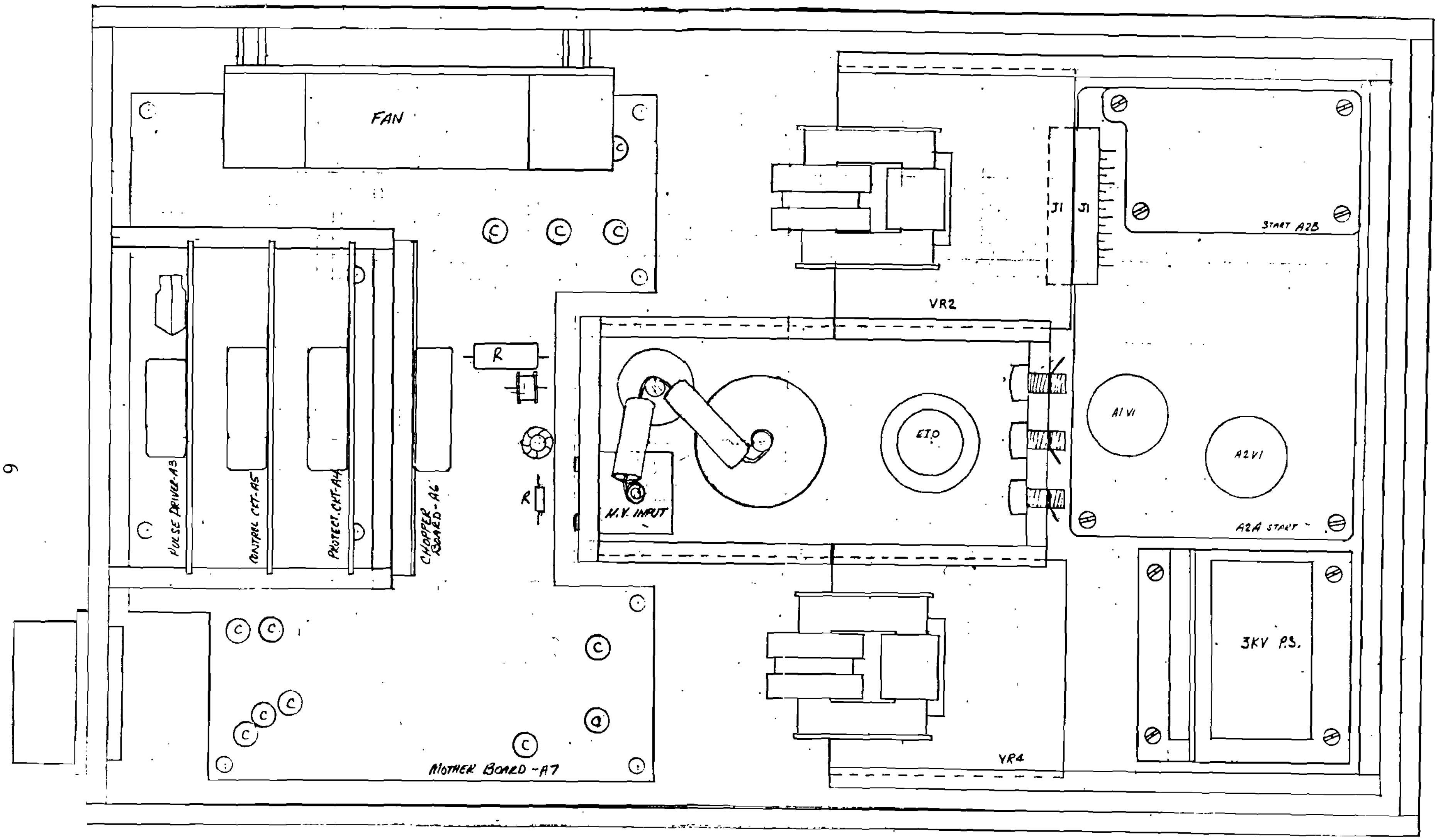


Figure 3. Interior of modulator assembly.

plate of the modulator enclosure is made of aluminum; special care must be taken when working with this plate since it floats at the beam potential of -21 kV.

Care must be taken when mounting the modulator assembly so as not to interfere with any interior components, especially the high voltage section. Mounting screws placed on the side plates opposite the high voltage section should not penetrate the potting material; they can penetrate only the depth of the outer aluminum plate (.25 inches). Care must also be taken not to interfere with the location of any other interior components, such as the fan and the four circuit cards, when inserting mounting screws into the side plates, that are not adjacent to the high voltage section.

Figure 4 is an illustration of the front panel of the power supply assembly. The power supply enclosure is designed for rack mounting in a standard 19 inch (48.3 cm) rack. The top cover of the supply can be removed for servicing.

2.3 OPERATION

DANGER - HIGH VOLTAGE - USE EXTREME CAUTION

When the assembly is fully set up, it is ready for operation. The front panel of the high voltage power supply, illustrated in Figure 4, contains all operator controls and indicators. Each control and indicator lamp is discussed individually, and then a standard power-up procedure is summarized to aid in the training of operators.

2.3.1 FRONT PANEL CONTROLS AND INDICATORS

The following is a discussion of the function of each control and indicator on the front panel of the power supply.

1) ON/OFF SWITCH - Applies prime power (230 VAC) when in the ON position.
2) ON/OFF LAMP - Is lit when prime power is applied.

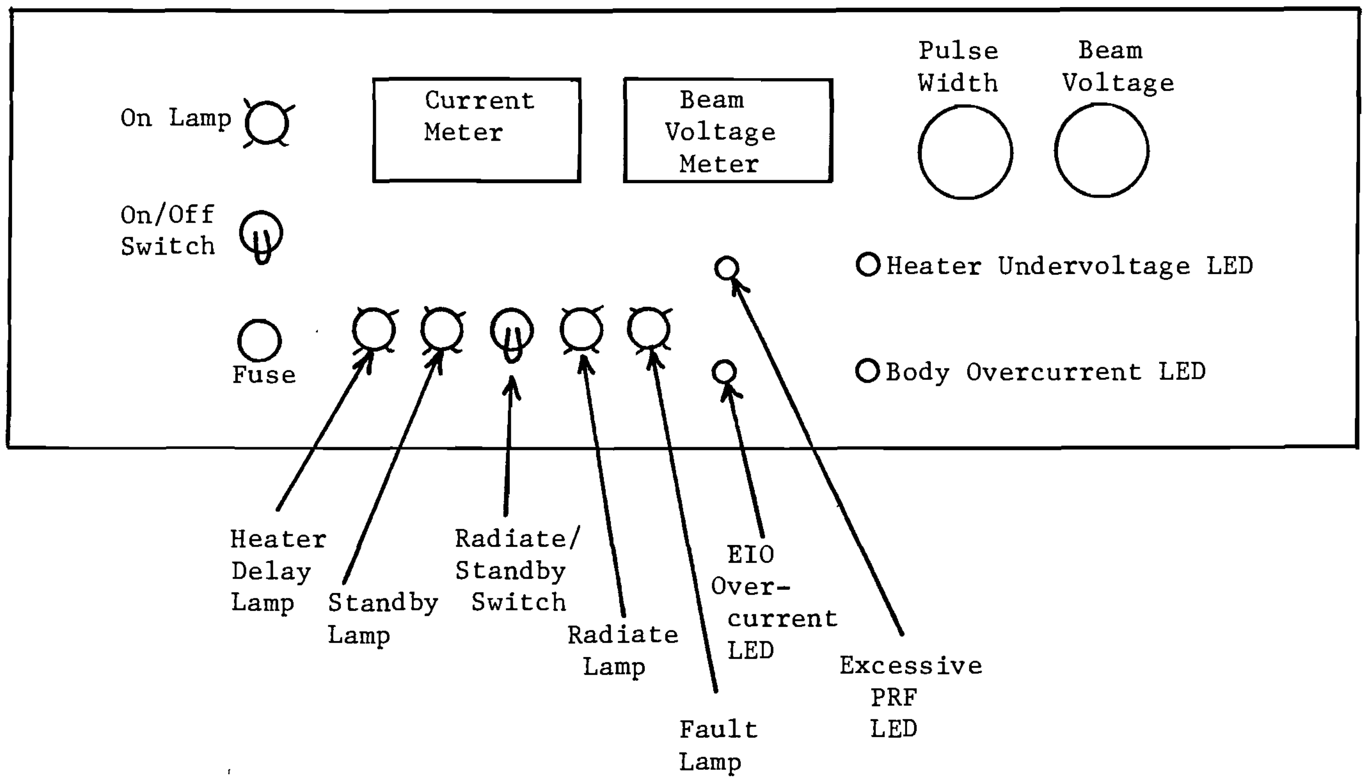


Figure 4. Power supply front panel.

3) HEATER DELAY LAMP - Stays lit for approximately two minutes after application of prime power. This delay allows the heaters of the RF tube and the planar triodes in the modulator to warm up so that the tubes operate properly when high voltage is applied. During the heater delay period, the system is automatically prevented from radiating in order to protect the tubes. After the heater delay the system automatically goes to STANDBY.

4) RADIATE/STANDBY SWITCH - Selects status of modulator. If the Heater Delay has timed out, switching to RADIATE applies high voltage to the modulator. If an attempt is made to go to RADIATE while in Heater Delay, the system will automatically ignore the attempt. After the Heater Delay, the system will go to STANDBY even though the switch remains in the RADIATE position. Switching to STANDBY cuts off the high voltage and also clears faults (see Fault Lamp for further explanation).

5) RADIATE/STANDBY LAMP - Indicates the status of the modulator, regardless of the RADIATE/STANDBY switch position.

6) FAULT LAMP - Lights up when a fault condition is detected by the protection circuit in the modulator. Four conditions are tested and faults are indicated by light emitting diodes (LEDs) (Fault LEDS are described next). When a fault is detected, the Fault lamp is lit along with the LED corresponding to that fault, and the system automatically reverts to STANDBY, shutting off high voltage to the modulator. When the fault condition is removed or corrected, the fault can be cleared by toggling the RADIATE/ STANDBY switch to STANDBY (if the fault is encountered while in STANDBY, the switch must be moved to RADIATE and then back to STANDBY in order to clear the fault. Since a fault condition exists, toggling the switch to RADIATE first will not cause the system to go to RADIATE). If a fault is encountered at power on, it will automatically clear itself after 6 seconds unless the fault still exists.

7) FAULT LED'S

a) Excessive PRF - The system will fault if the frequency of the synchronization signal is greater than the maximum design specification of 20 kHz. To clear this fault, decrease the frequency of the input synchronization signal and toggle the RADIATE/STANDBY switch as described above.

b) Heater Undervoltage - This indicates a low heater voltage in the RF tube. Operating an RF tube at high voltage with a low heater voltage can damage its cathode. If toggling the RADIATE/STANDBY switch does not clear the fault, the modulator must be inspected by qualified engineering personnel to determine the cause of undervoltage.

c) EIO Overcurrent - This indicates an excessive current drain on the high voltage power suply. If toggling the RADIATE/STANDBY switch does not clear the fault, the modulator/power supply must be inspected by qualified engineering personnel to determine the cause of the excessive current drain.

d) Body Overcurrent - This indicates an excessive absorption of power by the body of the RF tube, which can lead to its destruction. If toggling the RADIATE/STANDBY switch does not clear the fault, the modulator must be inspected by qualified engineering personnel to determine the cause of the fault (possibly a defocused beam).

8) PULSE WIDTH DIAL - This dial controls a multiturn potentiometer which sets the output pulsewidth. Table 2 correlates the dial setting with the actual output pulse width.

9) BEAM VOLTAGE DIAL - This dial controls the output of the high voltage power supply (0-25 KVdc) and sets the beam voltage of the RF tube.

10) BEAM VOLTAGE METER - Indicates the level of negative beam voltage applied.

11) CURRENT METER - Indicates the total amount of current drawn from the high voltage power supply (beam current plus body current).

2.3.2 SUMMARY OF POWER UP PROCEDURE

Table 3 summarizes the operating procedures for the modulator/power supply.

TABLE 2. PULSE WIDTH SETTINGS
(beam voltage set at 18.5 kV)

Setting on Pulse Width Dial	Output Pulse Width
00 (minimum)	35 ns
045	50 ns
332	100 ns
646	150 ns
975	200 ns
1000 (maximum)	205 ns

TABLE 3. SUMMARY OF OPERATION

CAUTION - HIGH VOLTAGE - USE EXTREME CAUTION

Operator Action	Modulator/Power Supply Status	Operator Response
Turn Power Switch ON	Power lamp lit	
	Heater Delay Lamp Lit for 2 Minutes	
	Fault lamp and an LED possibly on - will automatically clear after 6 seconds unless fault still exists	If fault does not automatically clear, attempt to clear it manually by toggling the Radiate/Standby switch. If the fault can not be cleared, shut off power and have engineering personnel determine cause of fault
	After 2 minute delay Heater Delay lamp goes out, Standby lamp comes on	
	Modulator now ready to Radiate	
Switch to RADIATE	Standby lamp goes out Radiate lamp comes on High voltage is applied to modulator	
Set Beam Voltge to Desired Level		

TABLE 3. SUMMARY OF OPERATION (CONTINUED)

Operator Action	Modulator/Power Supply Status	Operator Response
Set Pulse Width to Desired Level		
	A fault occurs	Attempt to clear fault by toggling Radiate/ Standby switch to Standby. If this does not clear fault have engineering personnel determine cause of fault
	If no faults occur, the modulator can be switched to and from Radiate with the Radiate/Standby switch	
Switch to Standby	Radiate lamp goes out Standby lamp comes on	
Turn Power OFF		

SECTION 3
THEORY OF OPERATION

This section is intended to aid the engineering personnel whose task is to make repairs or modifications to the modulator/power supply assembly. The paragraphs that follow discuss the theory of operation of the various individual circuits in the modulator. References are made to the schematic diagrams located in Appendix A to clarify the discussion. The basics of operation and the system block diagram, both in Section 1.2, should be reviewed before reading further in this section.

3.1 GENERATION OF OPTICALLY COUPLED PULSES

The high voltage pulse generated by the floating deck modulator is defined by the three optically coupled logic pulses generated by the Pulse Driver. Optical coupling is used to isolate the high voltage at the modulator deck from the ground referenced logic circuits used to form the pulses. Optical coupling provides better noise immunity and better isolation than commonly used pulse transformers.

The schematic diagram of the Pulse Driver is shown in Figure A-1 in Appendix A. The inputs to the circuit are the external synchronization signal and the pulsewidth adjust level from the front panel. A timing diagram is included in Figure 5 to illustrate the following discussion.

Integrated circuit (IC) one-shot U1a forms a positive pulse on the rising edge of the synchronization input defined by $.7C_1$ multiplied by the sum of the resistances R3 and the Pulsewidth Adjust potentiometer. This pulse is inverted in U2, a DS0026 MOS clock driver chip. The manufacturer's data sheets for the DS0026 are included in Appendix C. The high output current capability of the DS0026 is used to drive delay line U3, since normal TTL circuits can not supply enough current to drive these delay lines. The manufacturers data sheets on these delay lines are also included in Apendix C. NOR gate U4b combines the inverted pulse with its delayed version, producing a shorter positive level pulse than that produced by one-

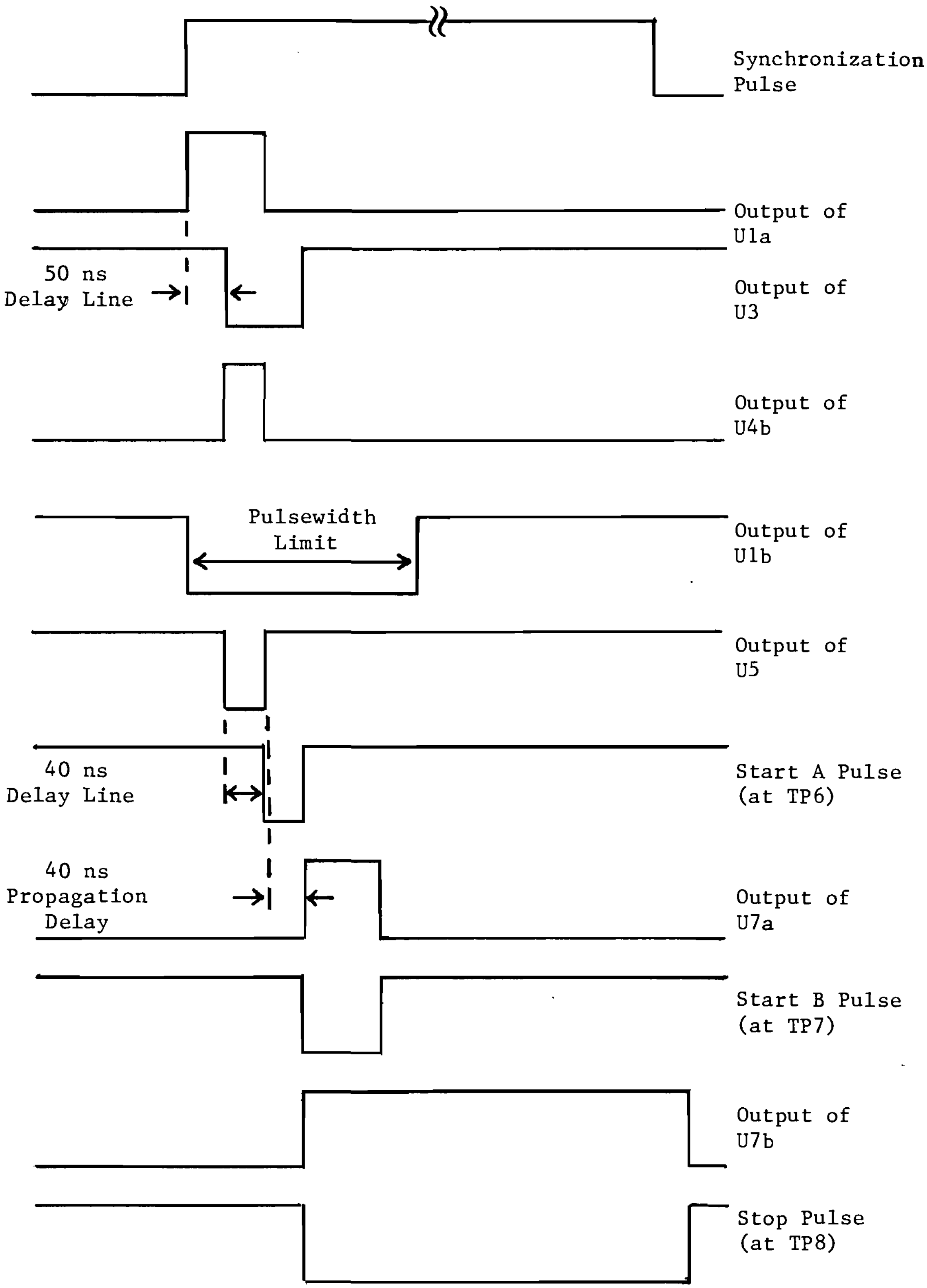


Figure 5. Timing diagram for pulse driver circuit.

shot U1a. This pulse is inverted with NOR gate U4c and combined with the output of one-shot U1b via NOR gate U4a. The output of U1b is a low level pulse which limits the pulsewidth set by U1a to a maximum value set by R2 and C3. The output of U4a is a positive pulse which is inverted in U5, another DS0026 driver, at TP5. The output of U5 drives delay lines U6 and U8 and is the input to one-shot U7a.

The output of U5 is delayed through U6; when the output of U6 goes low, the open collector output transistor of U9 conducts and allows current to flow through the LED in optical transmitter U11. This current flow produces the low level pulse START A (which can be viewed at TP6) that is optically coupled to the modulator deck.

The end of the pulse at TP5, i.e., its rising edge, causes one-shot U7a to form a positive pulse which triggers the START B pulse in the same manner as START A was formed. The leading edges of these two start pulses define the width of the pulse applied to the gates of the power FET's in the modulator. The two pulses are necessary because there is a 30 ns distortion at the receiver end of the optical link that prohibits receiving very short pulses. The logic used to combine the START A and START B pulses in the modulator is discussed in Section 3.2.

The rising edge of the delayed output of U8 triggers one-shot U7b, which forms the STOP pulse for the modulator in the same manner as START A and START B were formed. The use and significance of all three of these optically coupled pulses are discussed in the operation of the high voltage floating section of the modulator assembly.

3.2 FLOATING DECK MODULATOR OPERATION

Figure 6 is a simplified diagram of a floating deck modulator. Planar triode V_1 is referred to as the ON tube, while triode V_2 is called the OFF tube. Subsequently, the two circuit boards are referred to as the START deck and the STOP deck, respectively. As illustrated in Figure 7, when V_1 turns on, the grid-cathode voltage of the EIO rises from its cutoff bias of -3 kV to near 0 V with a rise time, t_r, set by the plate-to-cathode resis-

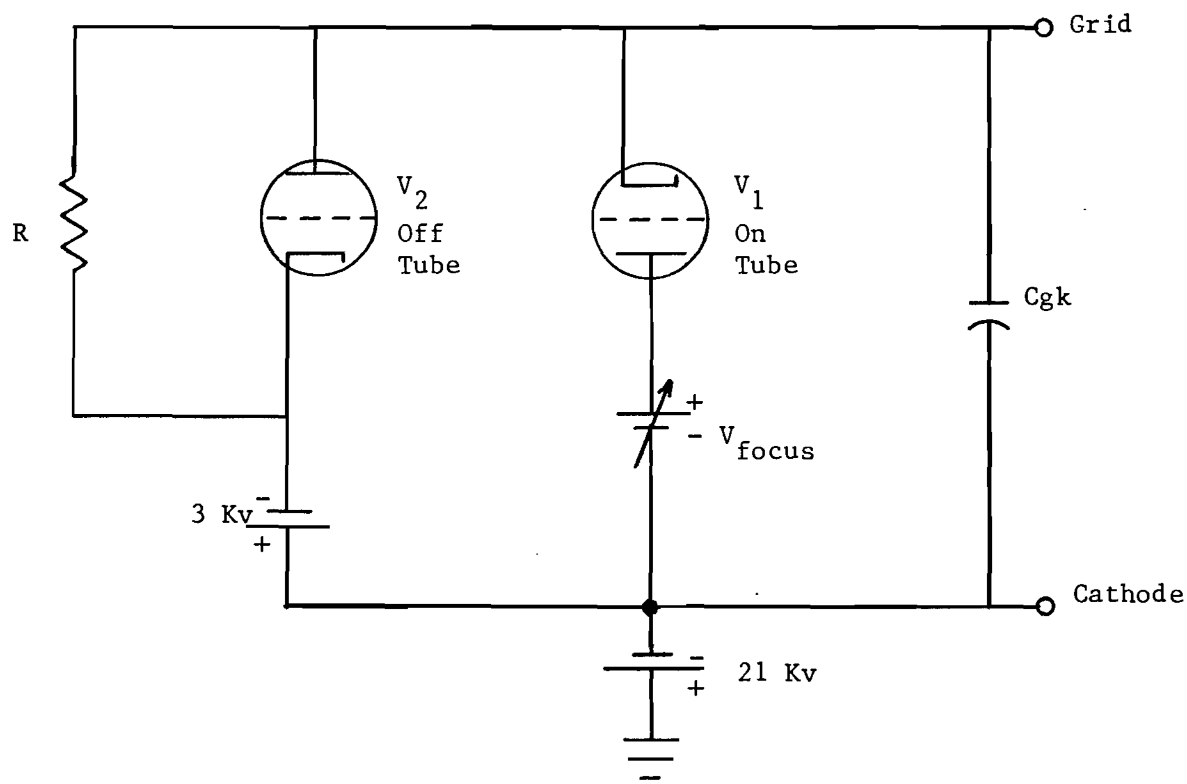


Figure 6. Simplified diagram of a floating deck modulator.

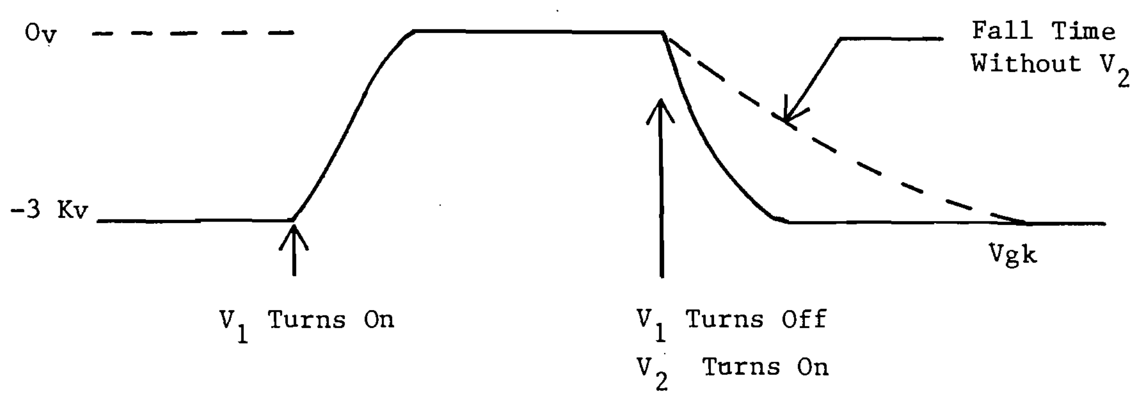


Figure 7. EIO grid to cathode voltage during pulse.

tance of V_1 and the sum of the EIO grid-cathode capacitance plus any stray circuit capacitance, or

$$t_r \approx 2.2 \times r_{pk_1} \times (C_{gk} + C_{stray}). \qquad (1)$$

The adjustable focus voltage compensates for the voltage drop across V_1 during the pulse, allowing the focus grid potential to be set very close to the cathode potential for proper operation. The focus grid of the EIO focuses the electron beam formed by the electron gun structure in much the same way as an optical lens focuses a light source into a narrow beam. When the grid is driven out of cutoff, the beam is defocused. Energy in the defocused beam is absorbed by he body, causing undesirable body current which can damage the EIO. The focus grid will properly focus the electron beam when the focus grid potential equals the cathode potential. Therefore, proper setting of the focus voltage and minimizing the rise and fall times of the grid pulse will minimize body dissipation.

The high voltage pulse is terminated when V_1 cuts off and V_2 turns on. The OFF or "tailbiter" tube forms a low impedance ($r_{pk_2} << R$) discharge path for the EIO and stray capacitances which results in a good fall time for the pulse. If V_2 were not present, the fall time of the pulse would be extremely long, set by R and C_{gk} instead of r_{pk_2} and C_{gk}. The output synchronization pulse is a sample of the collector current of the EIO; this pulse will be present only when the system is in radiate. Monitoring this signal will give an indication of proper modulator operation.

3.2.1 FORMATION OF THE PULSE

The schematic for the entire high voltage referenced section of the modulator is given in Figure A-3. Optically coupled pulses START A and START B are received and combined with digital logic to form a pulse with a width determined by the difference between the leading edges of the two pulses. This is necessary because the optical transmit-receive system introduces a trailing edge distortion, illustrated in Figure 8, that prohibits receiving very short pulses. Figure 8 also illustrates the form of the

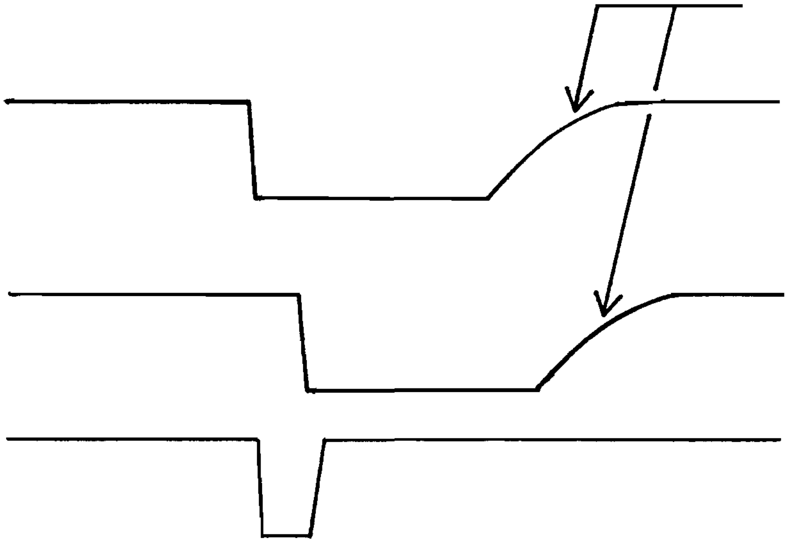


Figure 8. Illustration of trailing edge distortion of received optical pulses.

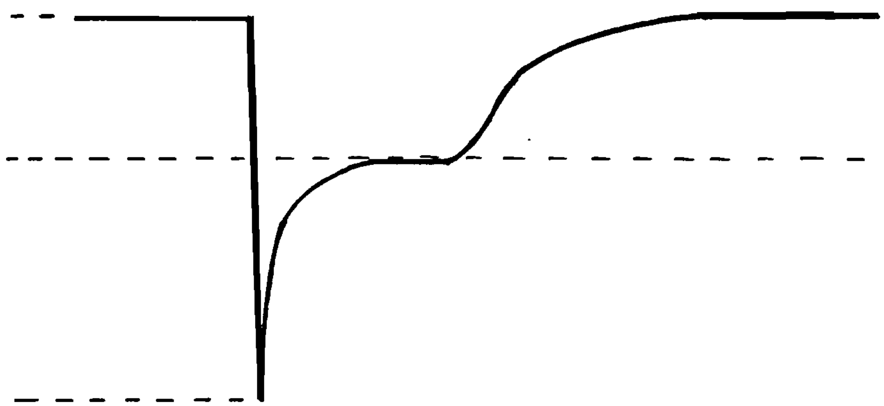


Figure 9. Shape of pulse at cathode of planar triodes.

output of circuit board A2B, which is mounted on the upper deck circuit board A2A.

The output of circuit board A2B forms the input to a set of three open collector drivers which drive a set of three DS0026 MOS clock drivers. The MOS drivers turn on three IVN6000CNT power MOSFETs, which pull down the cathode of the 8847A planar triode, thereby turning it on. The R-C network which connects the drains of the MOSFETs to the cathode of the planar triode sets the pulse shape at the cathode of the triode. Figure 9 illustrates the correct shape of the pulse at the cathode of the planar triode. The initial spike allows the triode to conduct a large surge of current that quickly charges up the EIO grid-cathode capacitance in order to obtain a good rise time. After the spike, the cathode settles to a level that keeps the tube in saturation for the flattest possible pulse. After the START pulse is finished, the cathode rises to a bias level set by the zener diode CR3.

The optically coupled STOP pulse forms the input to a MOS driver. No digital logic is needed here since the duration of the STOP pulse is not very critical. The operation of the STOP deck parallels that of the START deck and will not be repeated here. The formation of the high voltage pulse resulting from switching the planar triodes was discussed in Section 3.2.

3.3 PROTECTION CIRCUITRY

Due to the high cost of high power RF tubes, tube protection is an important aspect of modulator operation. The schematic of the protection circuitry is given in Figure A-7. The basic theory of operation of this circuit is to compare the monitored signals to a stable reference voltage using comparators. When the monitored signals reach critical levels, a comparator will change state, toggle and latch a flip-flop, and send a low level logic signal to the control circuitry indicating that a fault condition exists. Four signals are monitored: the synchronization signal pulse repetition frequency (PRF), the center tap voltage of the isolation transformer (T_1) that supplies the EIO heater voltage, the total EIO current, and the EIO body current.

The specification for the maximum operating PRF is 20 kHz. The protection circuitry will indicate a fault condition if the synchronization signal PRF exceeds 20 kHz. The synchronization signal triggers one-shot U1 which forms a fixed-width pulse which is then inverted and integrated. Therefore, the DC level obtained from the integration is a function of frequency only.

If the EIO heater voltage gets too low, the cathode of the EIO can be damaged when high voltage is applied to the tube. The center tap voltage that supplies the EIO heater voltage is monitored to give an indication if the EIO heater voltage drops below its minimum value. The center tap voltage is divided down with precision resistors, and this level is compared with a stable reference voltage.

The high voltage power supply has a floating ground terminal which allows for insertion of current monitoring circuitry between it and ground. The total EIO current flows from the floating ground terminal and through R_{10}. The collector or beam current flows out through pin J4-3, leaving the body current to flow through R_{11}. If the total current or body current of the EIO gets too high, one of the comparators will trigger and a fault will be declared.

The use of the $\overline{\text{Fault}}$ signal and the method used to reset a fault will be discussed next in a discussion of the control circuitry.

3.4 CONTROL CIRCUITRY

The schematic of the control circuitry is given in Figure A-9. The circuit operates as follows. Application of prime power at the front panel causes a rising edge at pin 2 of U3, a precision timer IC, which causes it to trigger a two minute (heater delay) low level logic pulse at its output pin 9. This logic "0" pulse causes flip-flop U7a to stay cleared which allows the circuit to prevent the modulator from going to the radiate mode while in heater delay.

Inverters U6a and U6b debounce the Radiate/Standby switch. Toggling this switch to Radiate causes a low to high transition at the clock input, pin 3, of flip-flop U7a. This sets the flip-flop unless the clear input, pin 1, is low. In other words, the system can not go to radiate during heater delay, if a fault is preent, or if the switch is in the Standby position. Switching to Standby automatically clears the flip-flop, taking the system out of the radiate mode.

The HVPS Enable signal is sent to the high voltage power supply. In the Radiate mode, this signal is a 15 V level that turns on the high voltage. When the system reverts to Standby or is in Heater Delay, this signal is approximately 0 V and disables the high voltage power supply.

Application of prime power also causes another precision timer U4 to trigger a six second logic "1" pulse. The purpose of this pulse is to automatically reset the protection circuitry after power-up, since the modulator will probably come on in a fault condition. This six second pulse is exclusive-ORed with the debounced setting of the Radiate/Standby switch. If this switch is in the Standby position at power up, as it should be, the circuit will automatically clear faults after the six seconds. If the switch is left in the Radiate position, the faults will not automatically be cleared; however, to go to Radiate would require switching to Standby first, which would clear the fault anyway. After the six second pulse ends, switching to Standby will clear any faults, as long as they are not still present at the time the attempt to reset is made.

When a fault is encountered, the $\overline{\text{Fault}}$ signal from the protection circuitry goes low and causes the Reset Command to go low and latch up the flip-flops within the protection circitry. Switching to Standby clocks flip-flop U7b and sets it, causing the Reset Command to go high, unlatches the flip-flops in the protection circuitry, and therefore clears the fault if it is no longer present. If the fault is still present it will not be cleared; the cause of the fault should then be determined.

3.5 HIGH VOLTAGE ISOLATED POWER SUPPLIES

Several voltages are necessary for operation of the floating deck modulator. These include heater voltages for the planar triodes and RF tube, +28 V for the -3 kV bias supply, the focus voltage, +5 V, +18 V, and +300 V for the various circuits used to form and amplify the pulse. since the entire START deck follows the 3 kV swing of the grid pulse, the operating voltages for the START and STOP decks must be isolated from each other. Four isolation transformers supply the necessary operating voltages to the floating deck modulator. Table 4 lists how the various voltages are distributed among the four isolation transformers.

TABLE 4. DISTRIBUTION OF HIGH VOLTAGE ISOLATION TRANSFORMER VOLTAGES

Transformer	Secondary Voltages
T1	Operating voltages for STOP deck; +300 V, +18 V, +5 V Heater voltages for planar triode and RF tube
T2	+28 V for -3 kV bias supply
T3	Operating voltages for START deck; +300 V, +18 V, +5 V Heater voltage for planar triode
T4	Focus voltage

The secondary voltages of the four transformers are supplied by the center-tapped primaries of four driven push-pull power converters. The schematic for the push-pull converters is given in Figure A-11 in Appendix A. The schematics of the four transformers are given in Figures A-13 and A-14. In Figure A-11, U1 is a SG1525A complementary output square wave generator, and U3 is a DS0026 MOS driver which drives the gates of all eight switching FET's. The FET's used are the IRF520, and manufacturers' data sheets for them and for the SG1525A and DS0026 are included in Appendix C. The center-taps of T1, T3, and T4 are adjustable via voltage regulators in the low voltge power supply; the center-tap of T2 is +24 V, since additional regulation is supplied by the input of the -3 kV supply itself.

3.6 HIGH VOLTAGE POWER SUPPLIES

3.6.1 BEAM SUPPLY

The high voltage power supply used to supply the beam voltage (-21 kV) was manufactured by the Spellman High Voltage Electronics Corporation. The manufacturer's instruction manual for this high voltage power supply is given in Appendix D and includes the specifications and schematics for the power supply.

Several modifications have been made to the beam supply. One modification was the inclusion of the low voltage power supply within the high voltage power supply enclosure. The additional connector was added to the back of the supply to allow for a cable that carries voltages from the low voltage supply and commands from the front panel switches to the modulator and carries status and control signals from the modulator back to the front panel. Figure 10 is a sketch of the location of the additional components within the Spellman supply.

3.6.2 BIAS AND PULSER SUPPLY

The bias and pulser supply is a -3 kV supply made by the Advanced High Voltage Corporation. The manufacturer's specifications for this power supply are given in Appendix C. This supply provides the -3 kV grid bias necesary to keep the EIO cutoff. Formation of the 3 kV pulse is described in Section 3.2. The -3 kV supply is located within the modulator assembly.

3.7 LOW VOLTAGE POWER SUPPLY

The low voltage power supply assembly is located within the high voltage power supply. The schematic for the low voltage power supply is

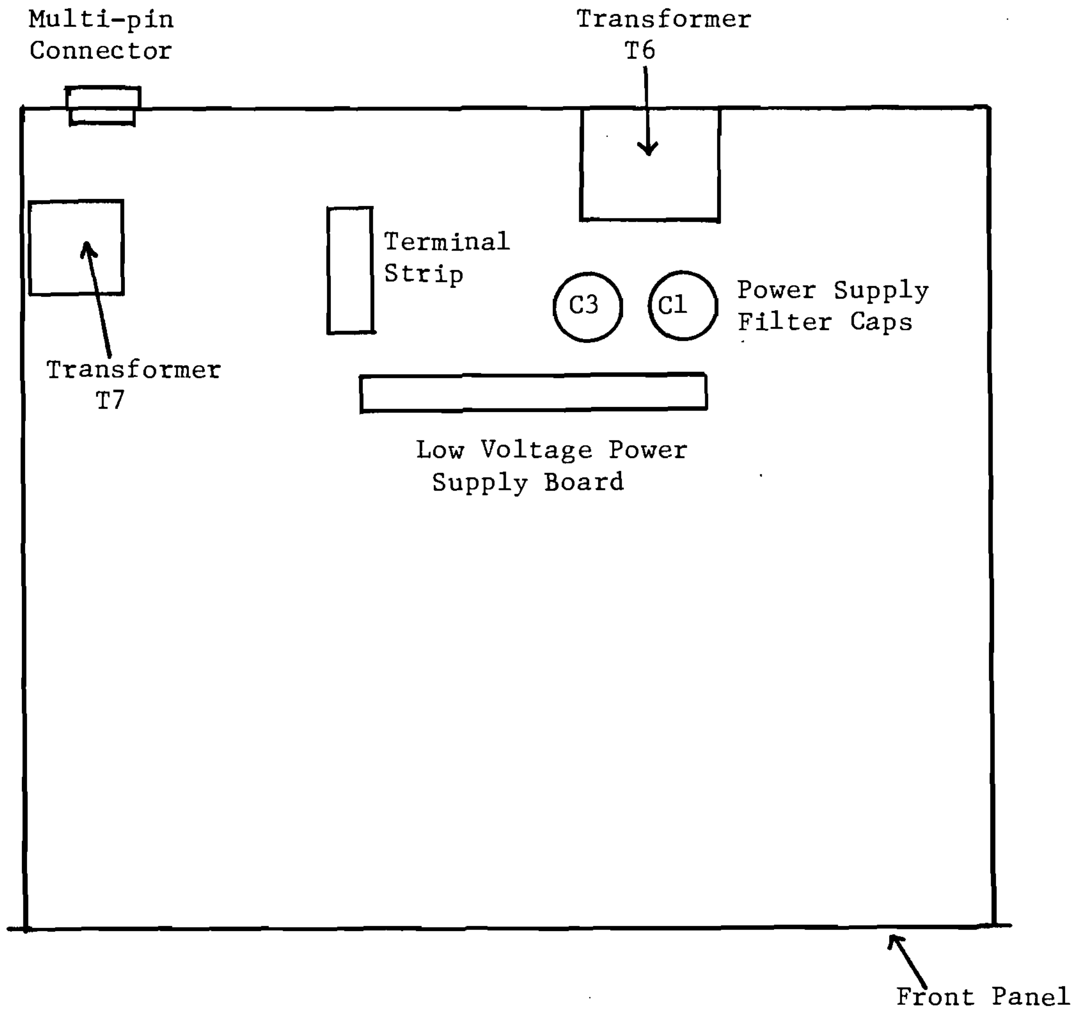


Figure 10. Location of added components to high voltage power supply (top view).

given in Figure A-19. The power supply consists of two 230 V to 24 V transformers followed by appropriate filtering and regulating circuits. Transformer T6 supplies power for the center taps of the isolation transformers and also for the fan within the modulator and the lamps on the front panel of the high voltage power supply. Transformer T7 supplies power for the control, protection, pulse driver, and push-pull converter circuits.

3.8 INTERCONNECTING CABLES

Three cables connect the modulator and the high voltage power supply. A multiconductor cable carries DC power supply voltages and control and status commands to and from the modulator and beam supply front panel. A BNC cable carries the HVPS Enable command from the control circuitry in the modulator to the beam supply. The high voltage cable connects the beam supply to the floating deck modulator. A diagram for the interconnection board is given in Figure A-21. Note that input and output synchronization signal BNC jacks are located on the modulator assembly.

3.9 TROUBLESHOOTING

This section deals with the four fault conditions that result in automatic shutdown of the modulator. The majority of service required for the system should deal with these four conditions. Each fault is discussed individually along with possible causes for the fault. This should help minimize repair time.

3.9.1 EXCESSIVE PRF

This fault occurs when a synchronization signal with a frequency greater than 20 kHz is applied to the modulator. Decreasing the frequency of the input signal should clear this fault. If it does not, refer to the discussion in Section 3.3 dealing with this condition. A possible circuit failure might be a faulty one-shot setting; adjust potentiometer R_1 (see Figure A-7), for a 26.5 μs pulse at TP2. If this does not correct the circuit, check for failure of the integrated circuits used.

3.9.2 EIO HEATER UNDERVOLTAGE

This fault occurs when the center tap voltage of isolation transformer T1 gets too low indicating that the secondary voltage that supplies the heater voltage for the EIO has also dropped. Possible causes for this fault are excessive power drain by the other secondaries of T1, or maladjustment or failure of the voltage regulator Q6 that supplies the center tap voltage (see Figure A-21).

3.9.3 TOTAL EIO AND BODY OVERCURRENT

The protection circuitry (Figure A-7), samples the total current flowing from the high voltage power supply. This current flows through R_{10}, and the collector current flows back out of the circuit, leaving the body current to flow to ground through R_{11}. Total EIO overcurrent can result from an arc within the EIO. Body overcurrent results from an improperly focused beam. Adjusting the focus voltage via the voltage regulator Q5 that feeds the center tap of isolation transform T4 should correct any beam defocusing.

SECTION 4
SUMMARY

This operations manual was written with the following as goals:

1) To provide sufficient explanation of the operation of the modulator/ power supply assembly so that operators can be easily trained; and

2) To provide detailed explanation, including diagrams and schematics of the individual circuits within the modulator. This discussion should aid Philips' engineers who wish to modify or repair the assembly.

All circuit schematics and parts location drawings for each circuit board are given in Appendix A. Parts lists for the various circuits are given in Appendix B. Manufacturers' specification sheets for selected components are given in Appendix C. The instruction manual for the -21 kV beam supply is given in Appendix D.

APPENDIX A

SCHEMATICS AND PARTS LOCATION DIAGRAMS

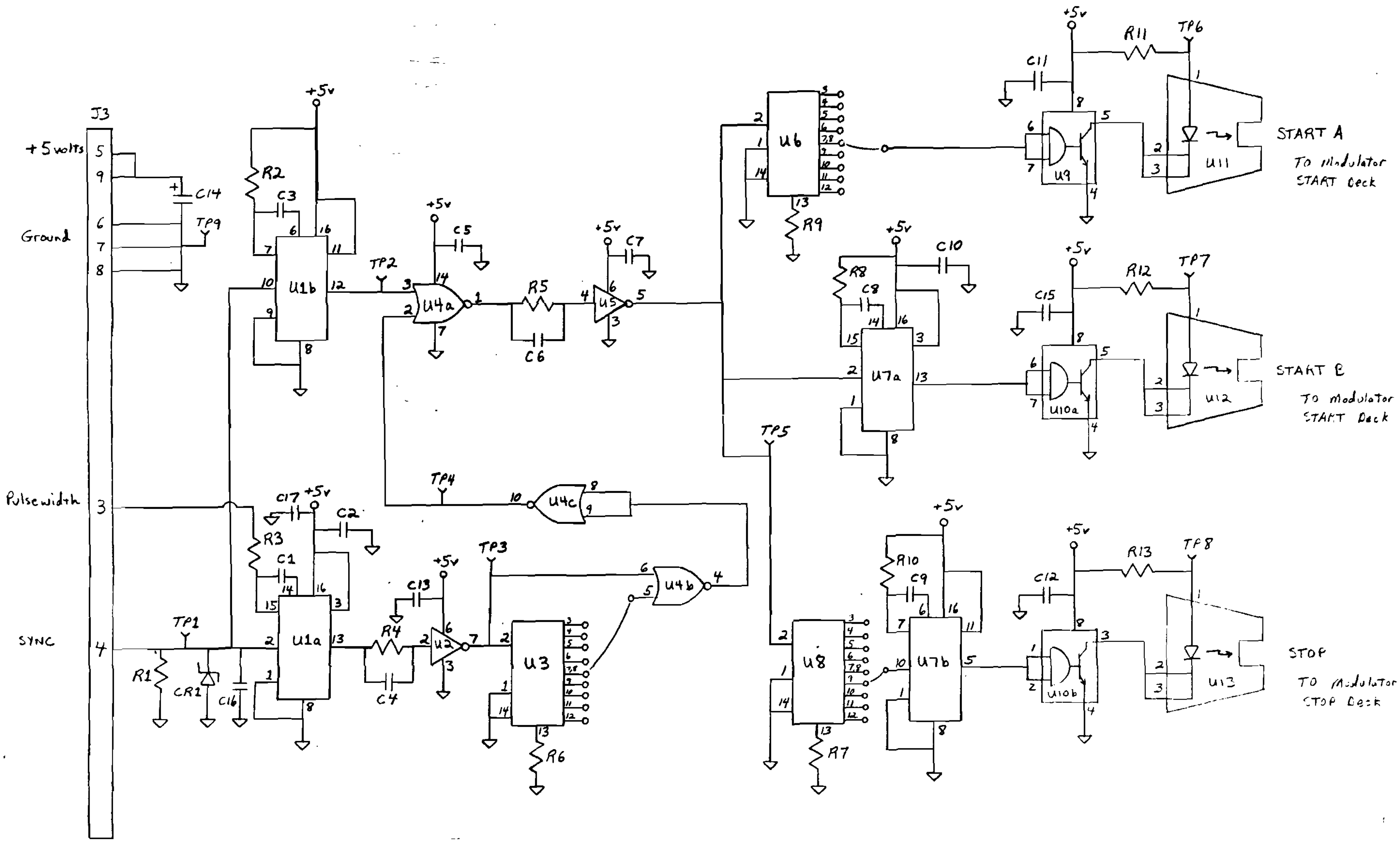


Figure A-1. Schematic diagram for Pulse Driver Circuit.

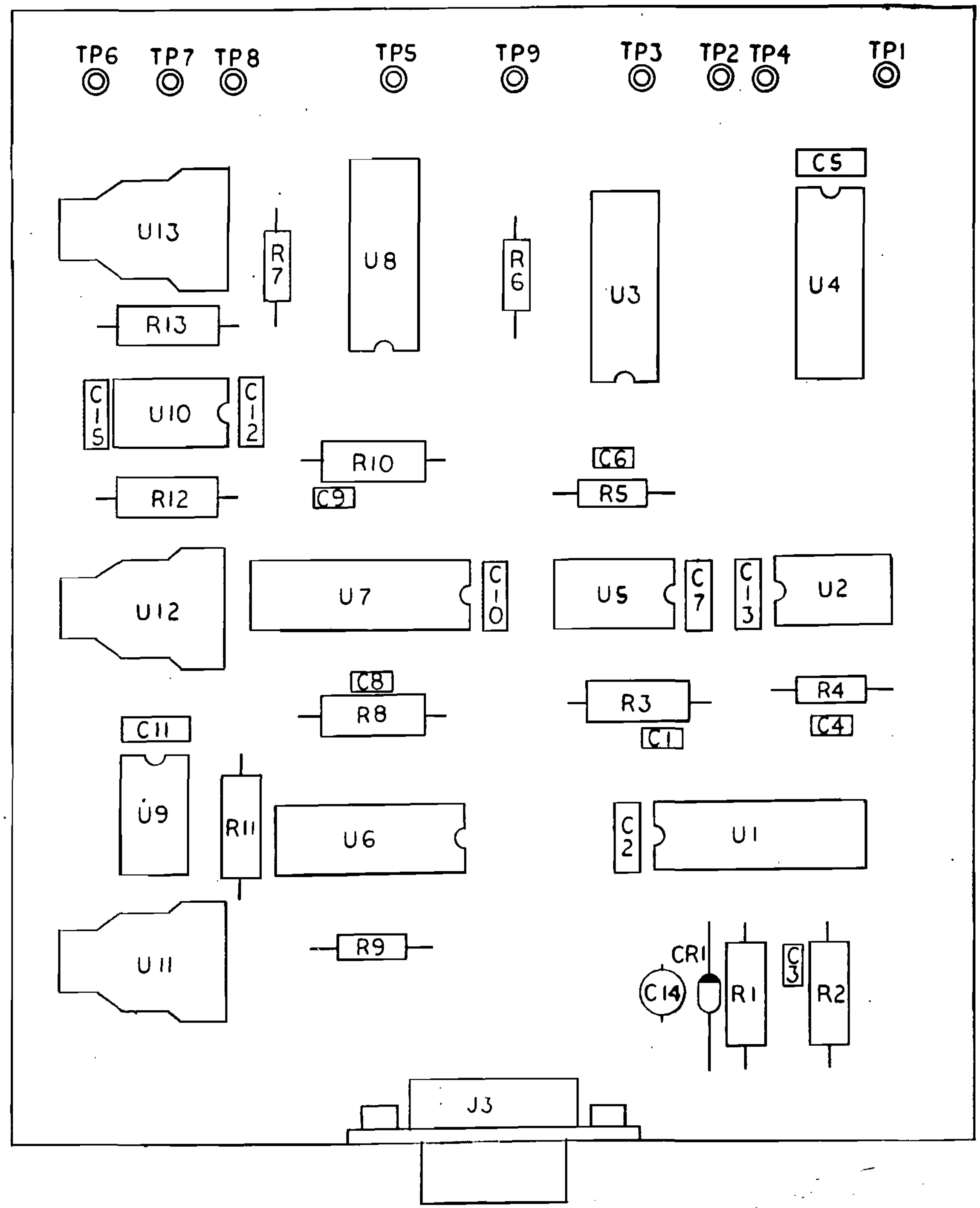


Figure A-2. Parts location diagram for Pulse Driver Circuit.

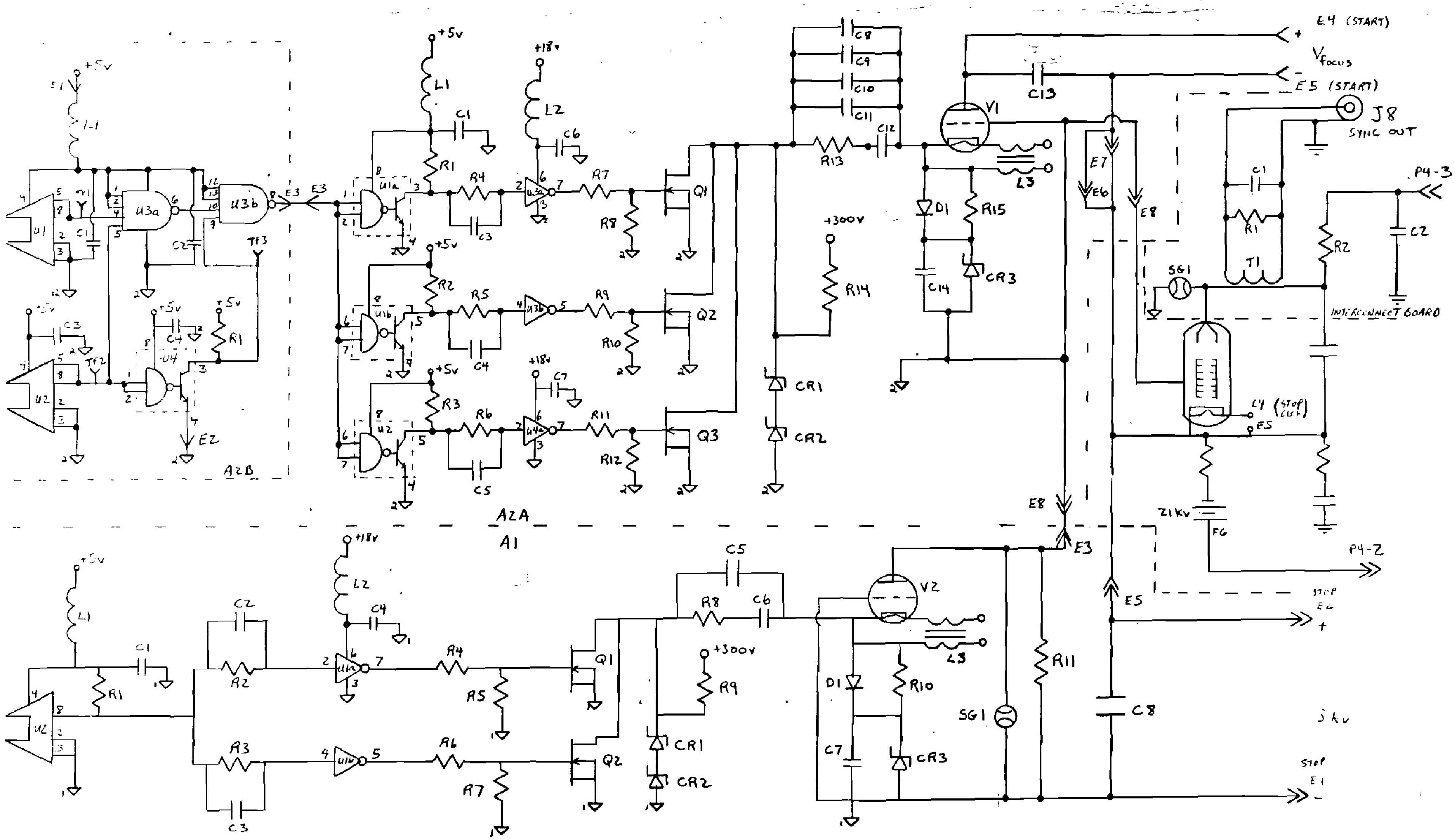


Figure A-3. Schematic diagram for modulator circuitry.

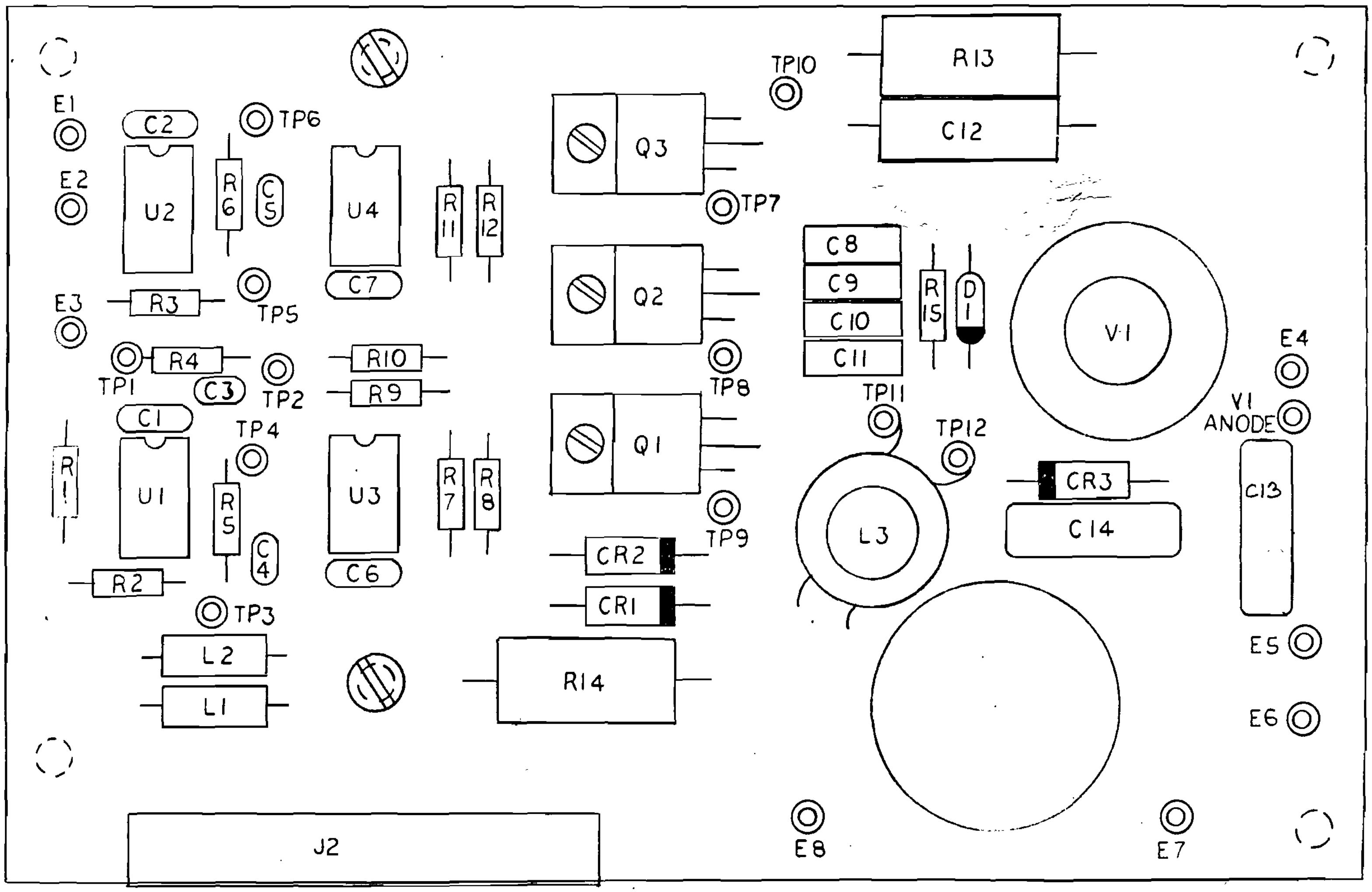


Figure A-4. Parts location diagram for modulator Start Deck A2A.

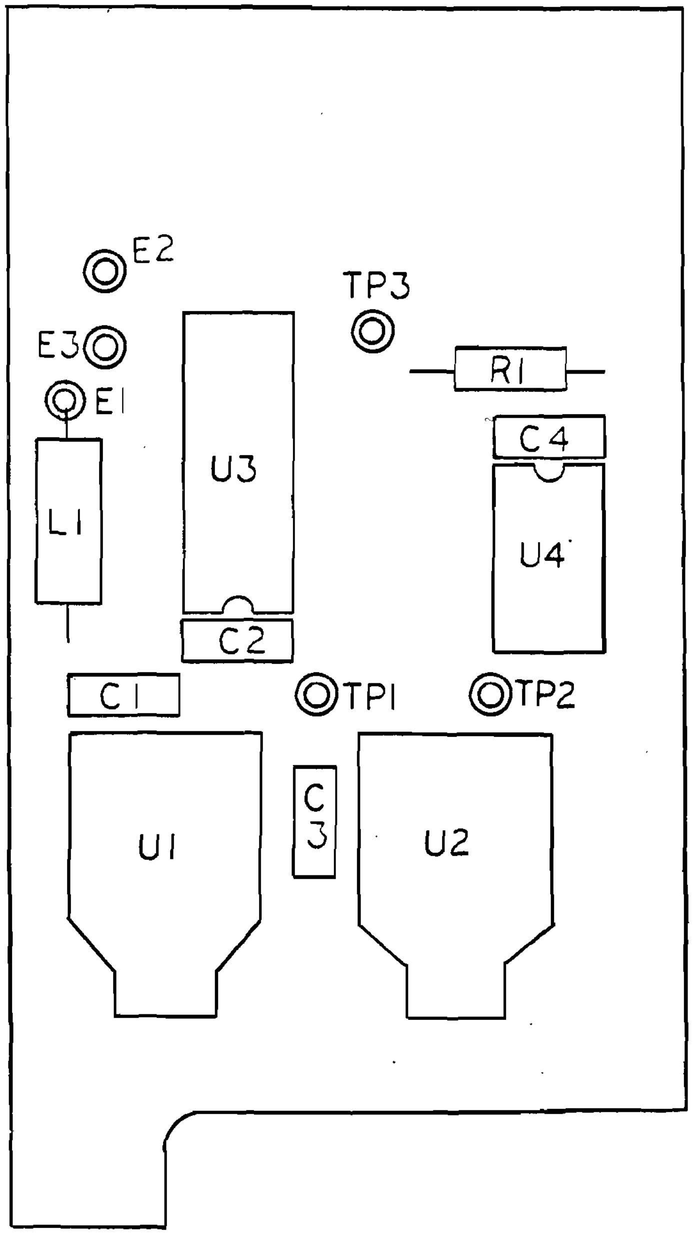


Figure A-5. Parts location diagram for modulator Start Deck A2B.

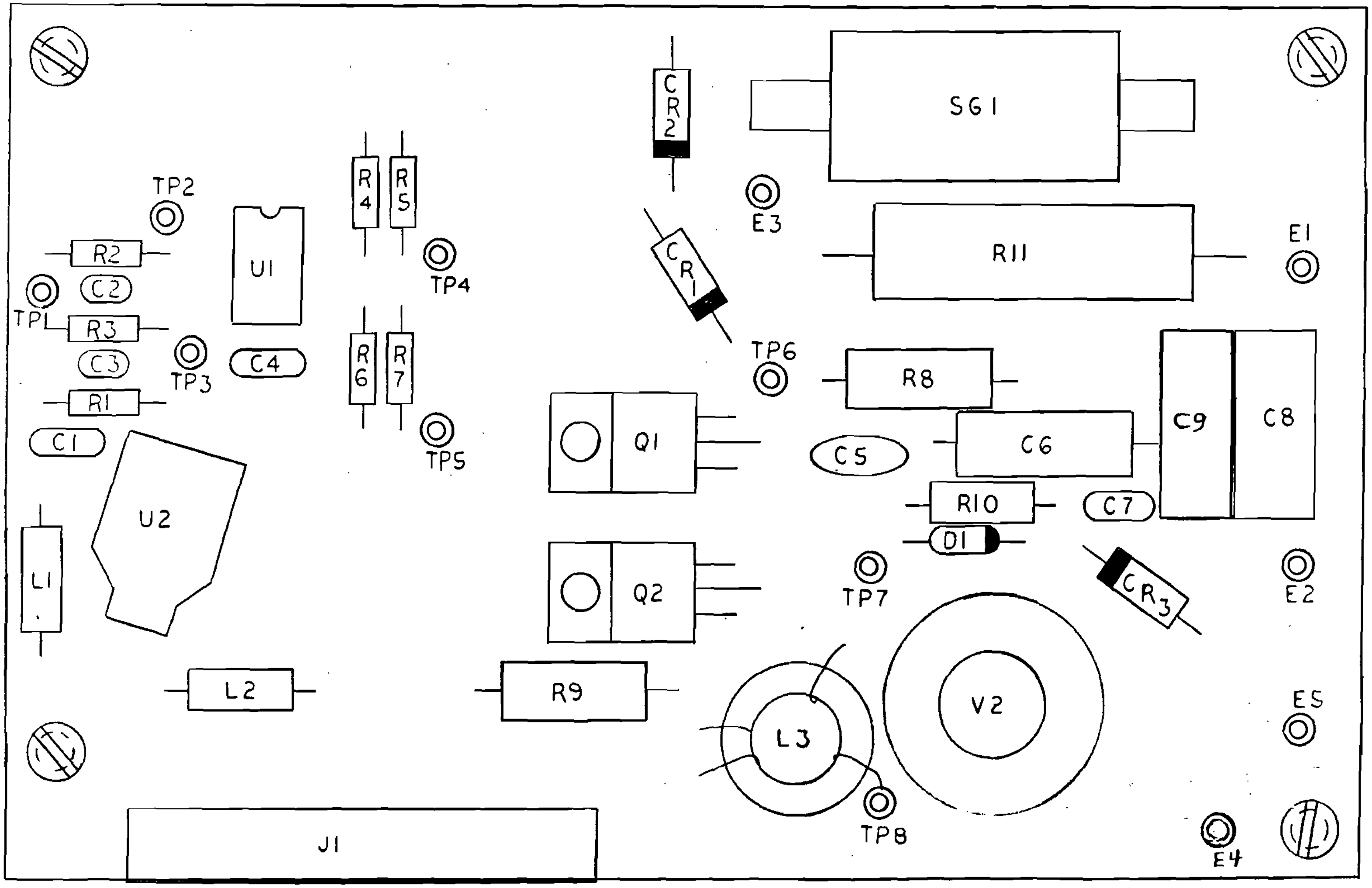


Figure A-6. Parts location diagram for modulator Stop Deck.

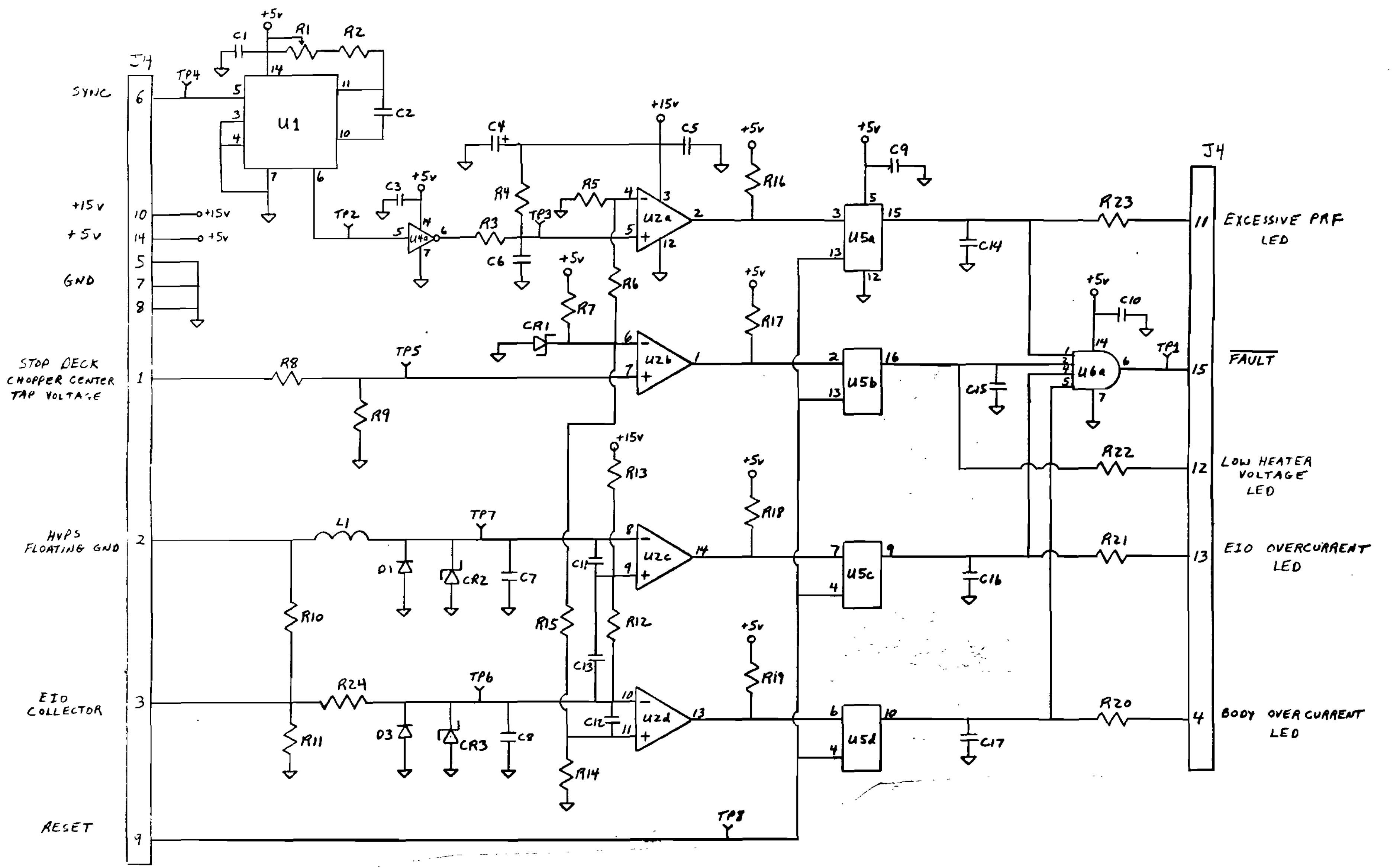


Figure A-7. Schematic diagram of Protection circuit.

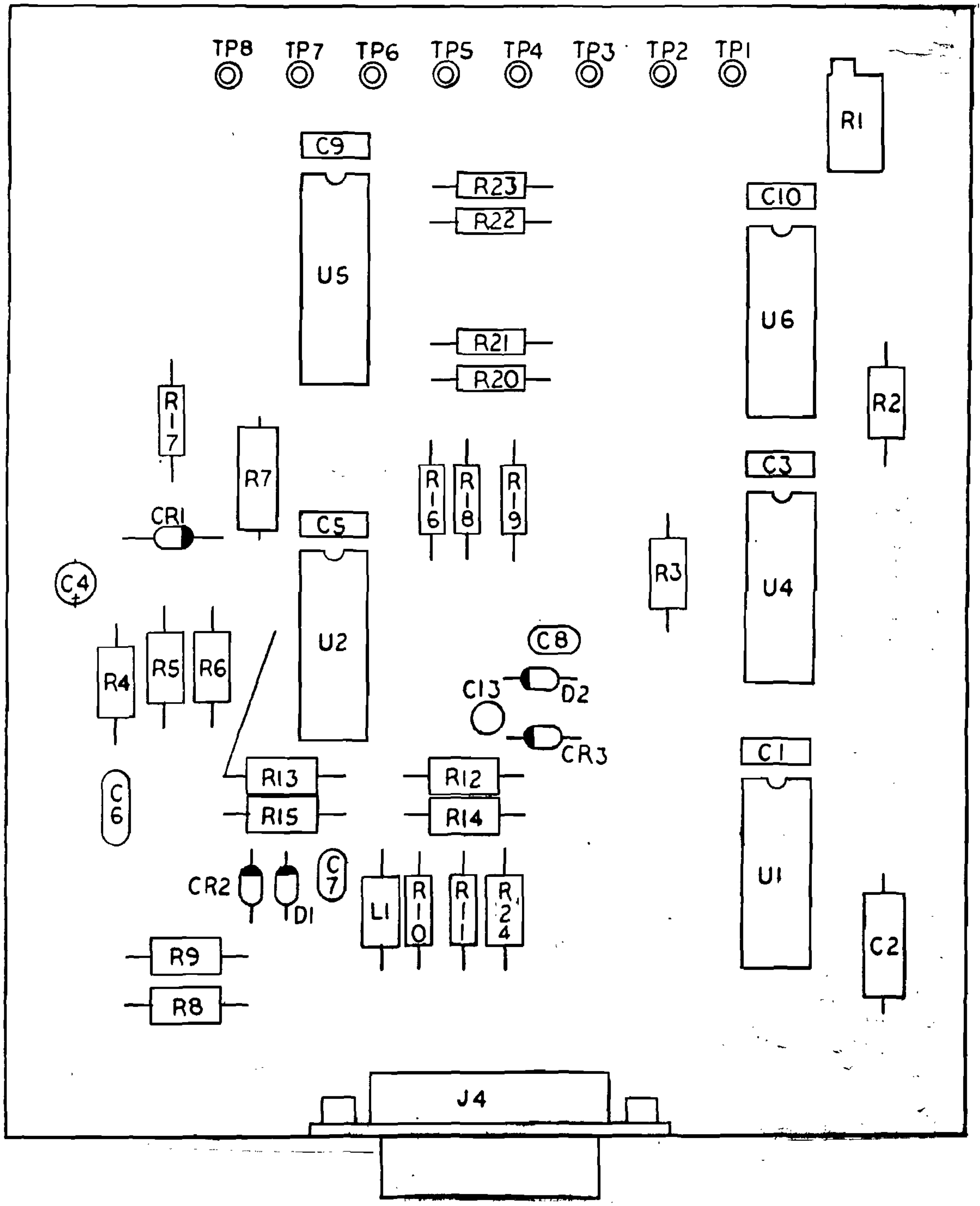


Figure A-8. Parts location diagram for Protection circuit.

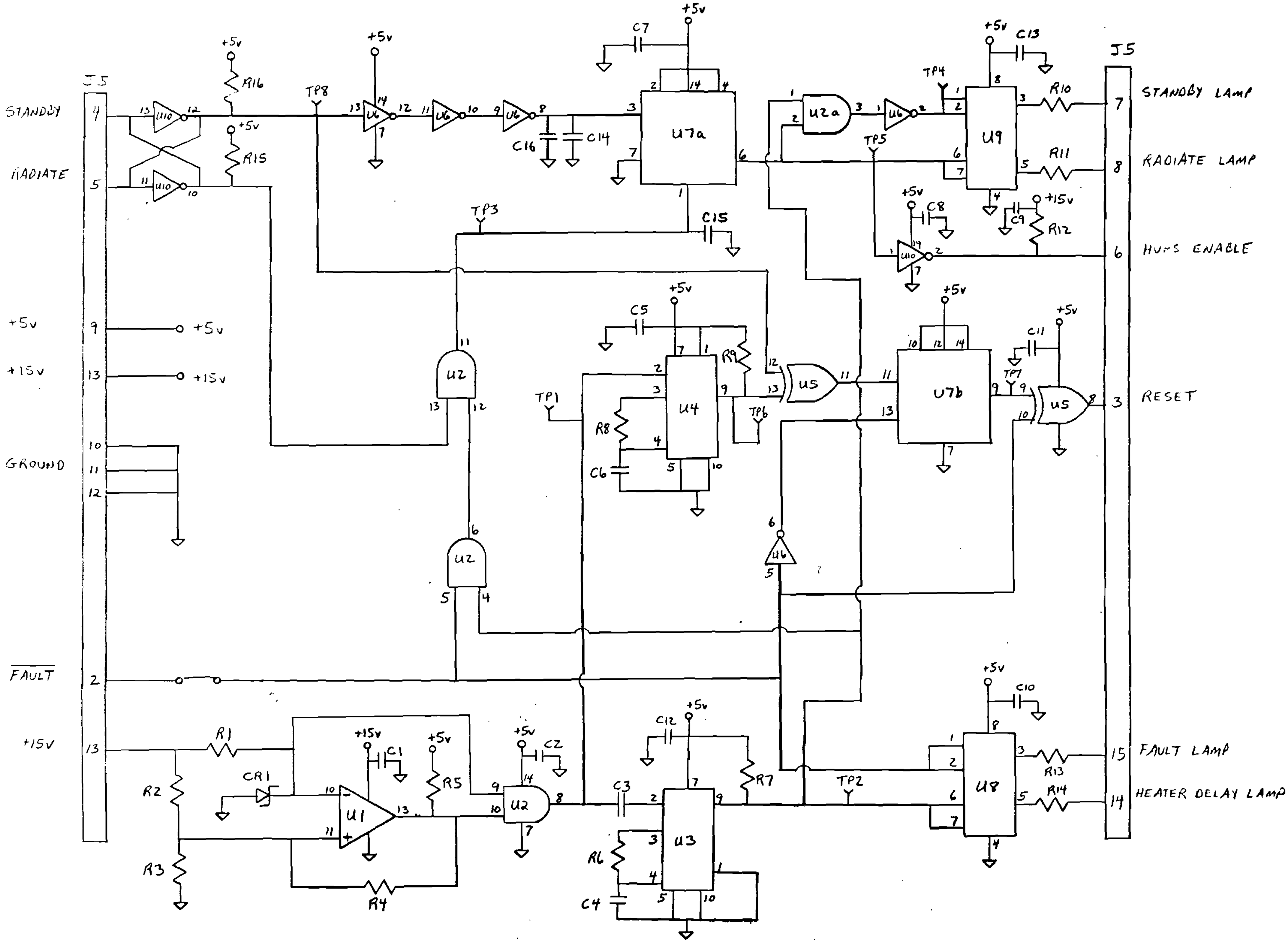


Figure A-9. Schematic diagram for Control circuit.

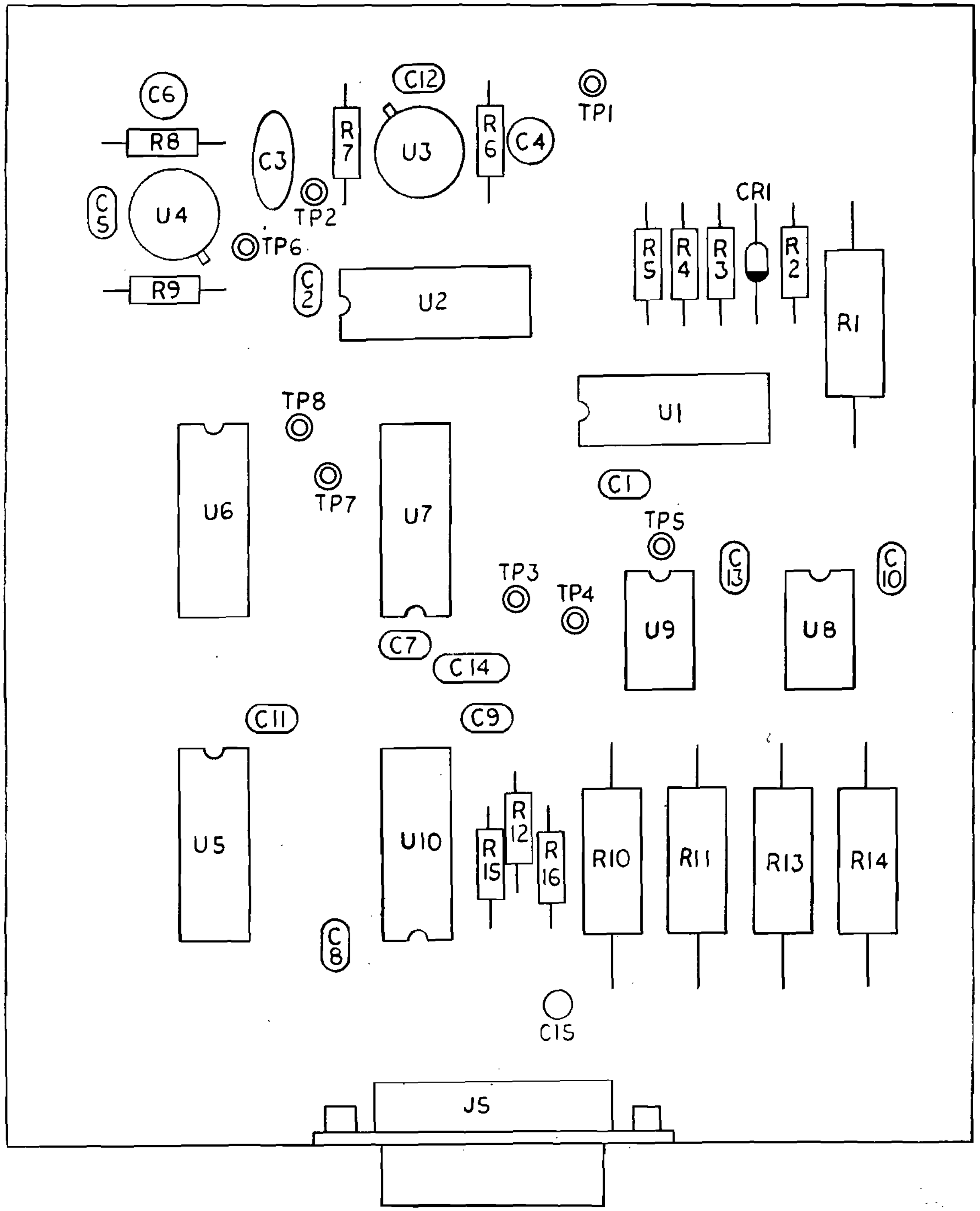


Figure A-10. Parts location diagram for Control circuit.

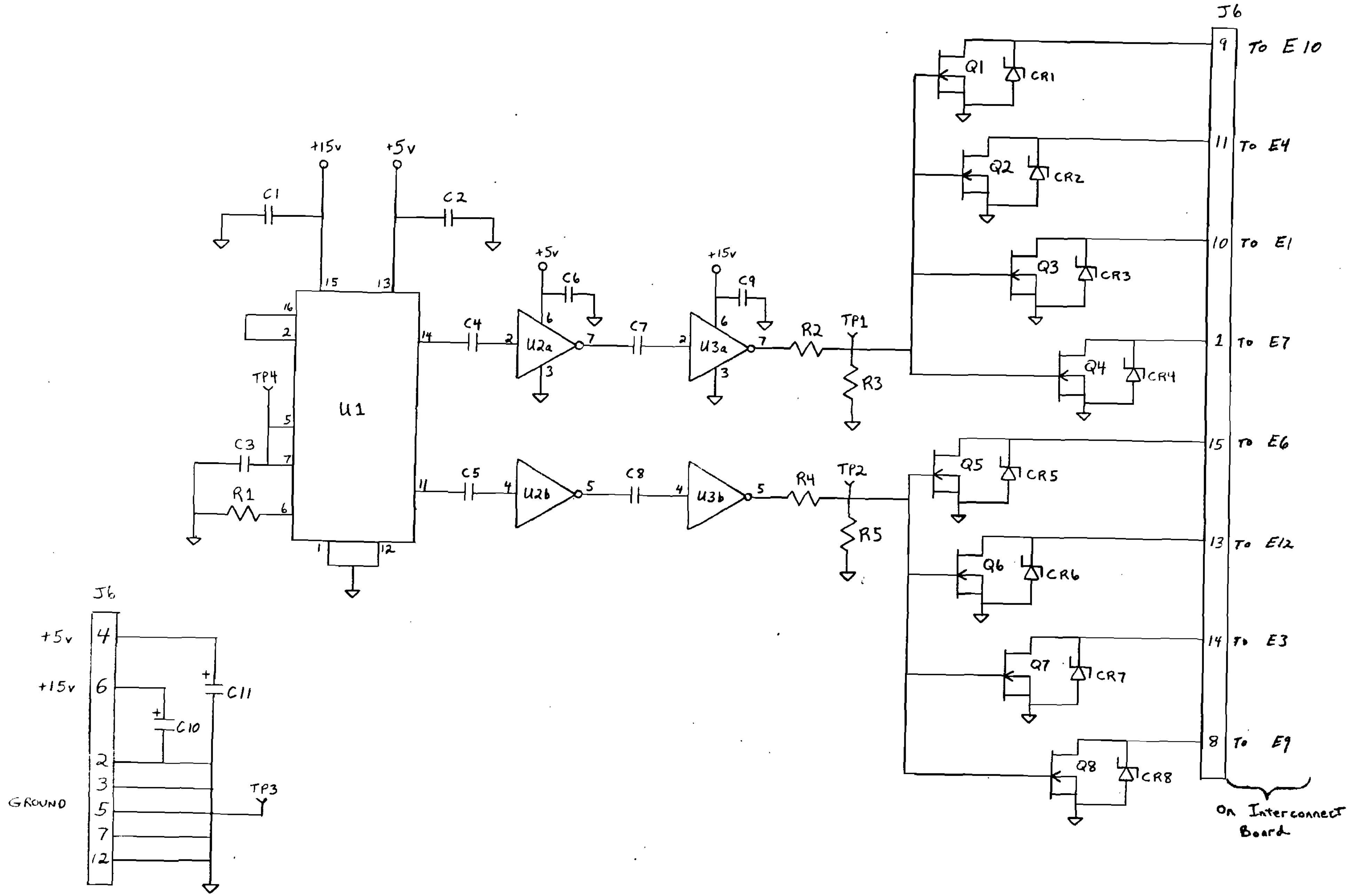


Figure A-11. Schematic diagram of push-pull power converter (chopper) circuit.

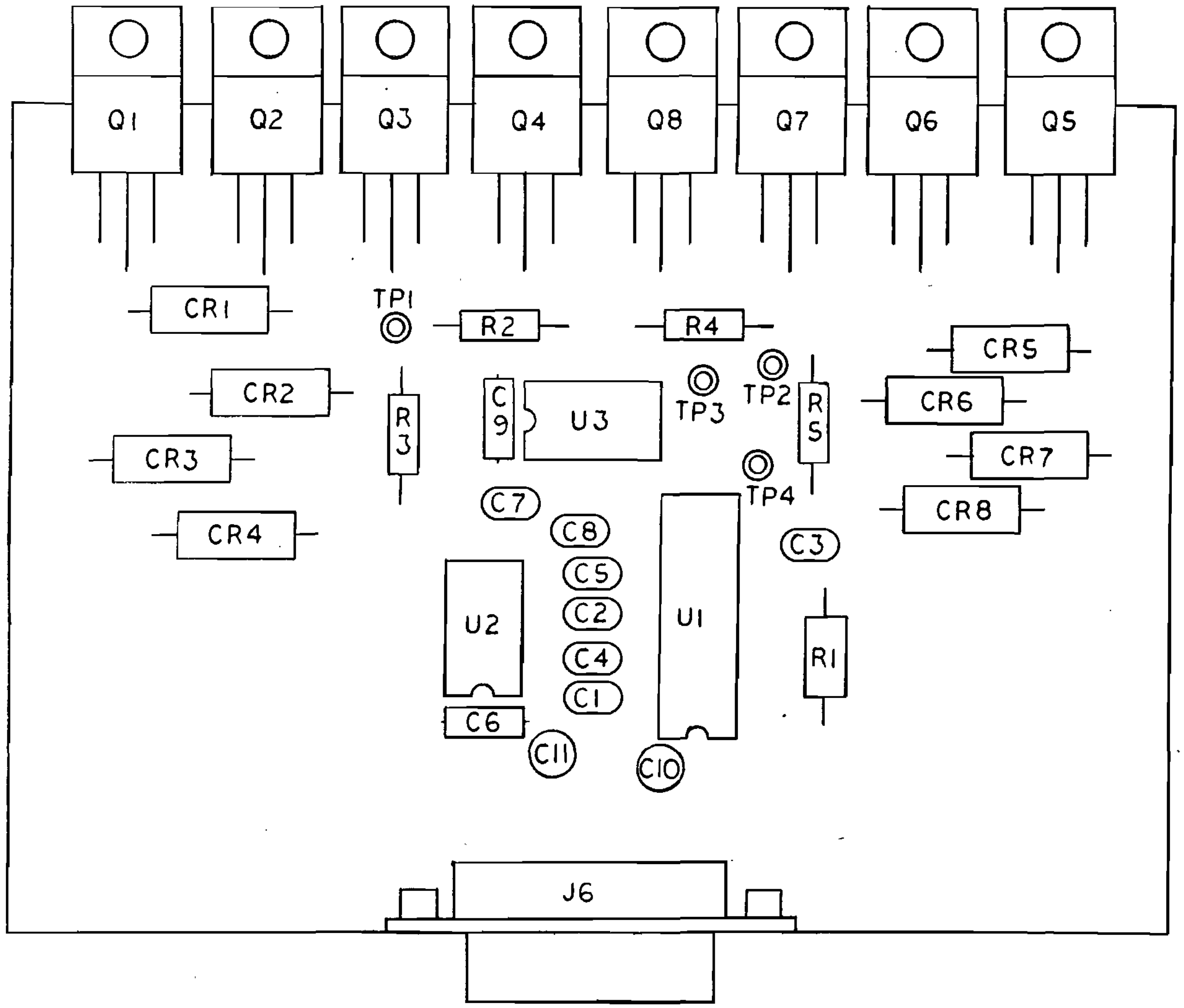


Figure A-12. Parts location diagram for push-pull power converter (chopper) circuit.

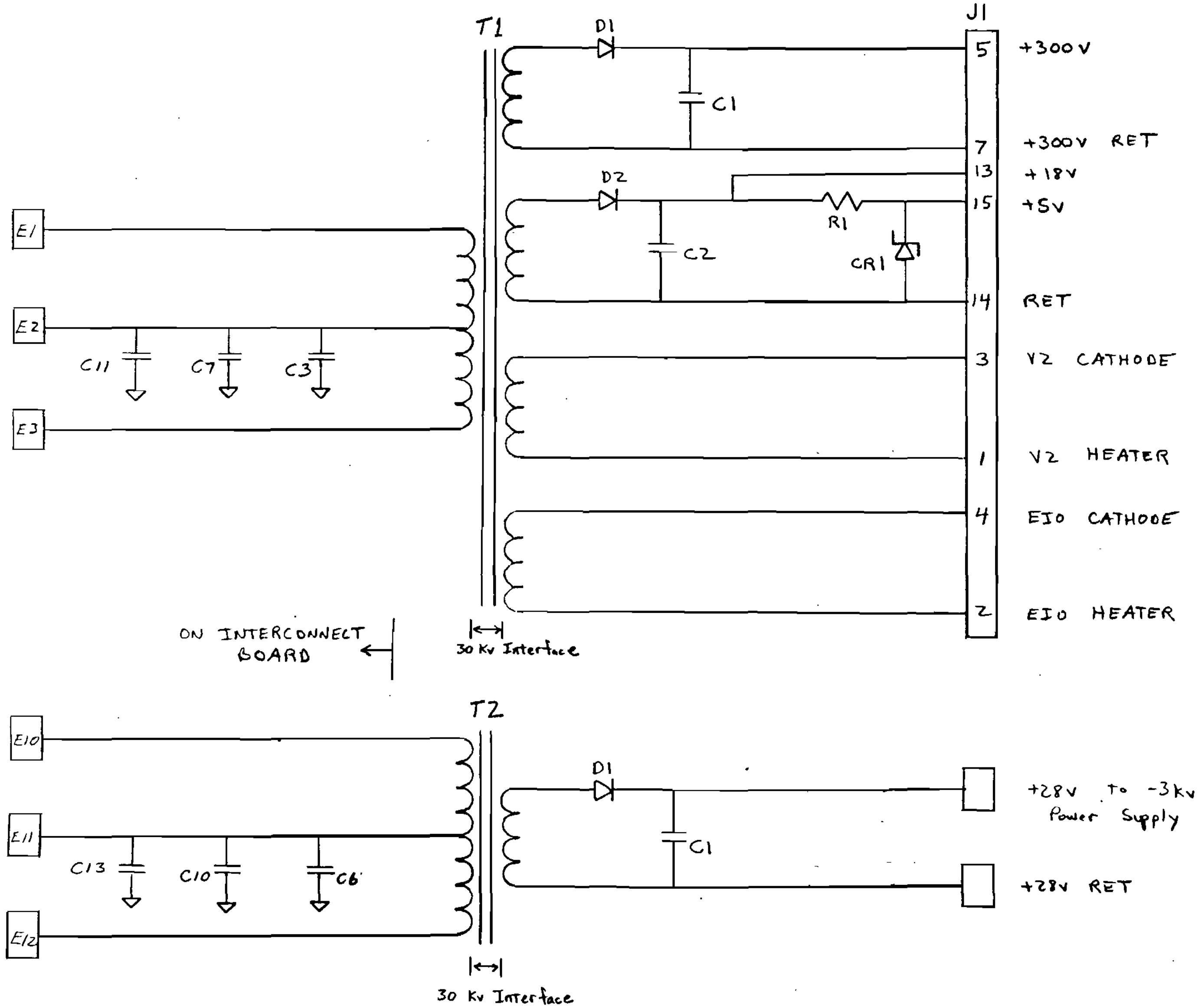


Figure A-13. Schematic diagram for isolation transformer supplies T1 and T2.

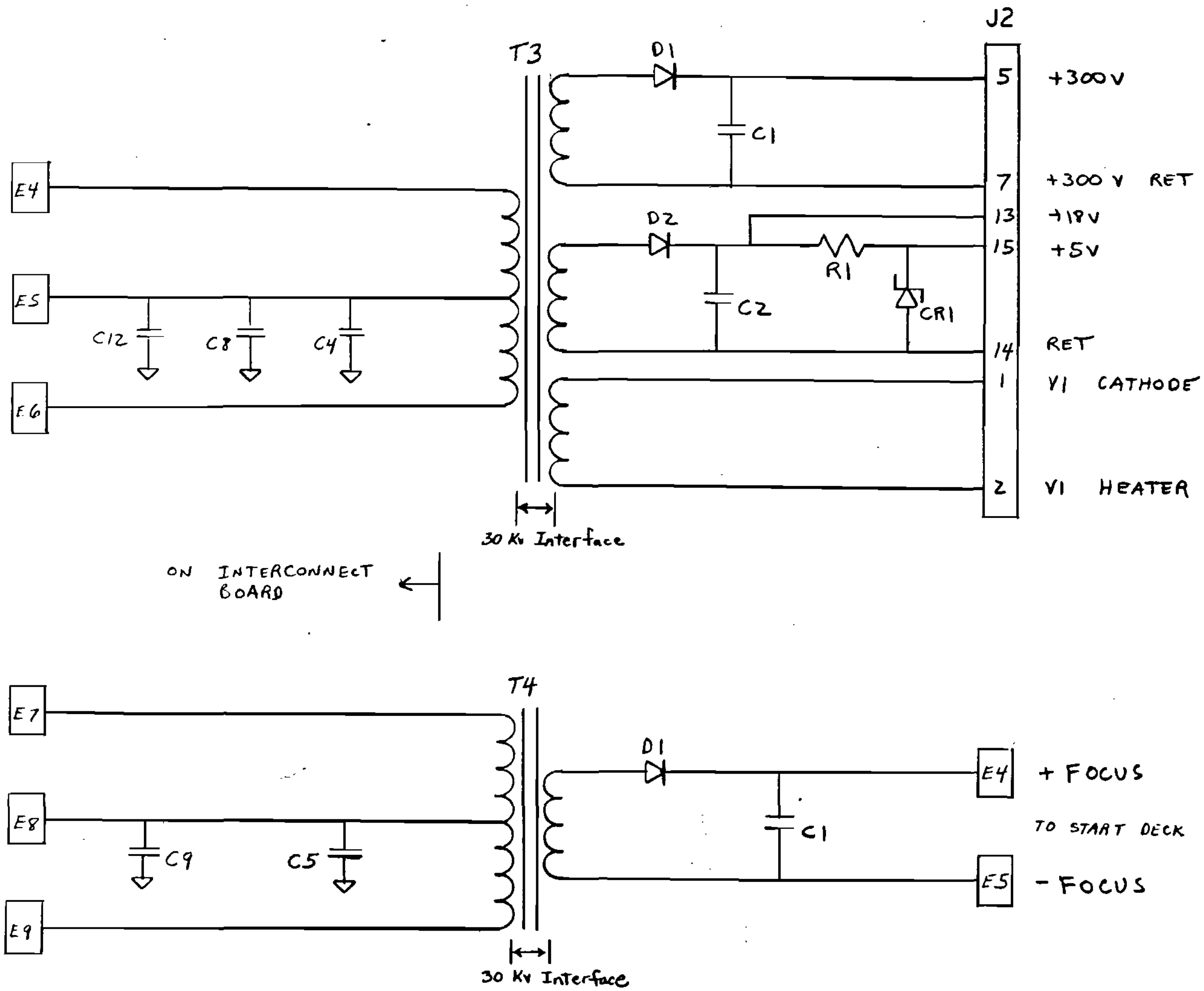


Figure A-14. Schematic diagram of isolation transformer supplies T3 and T4.

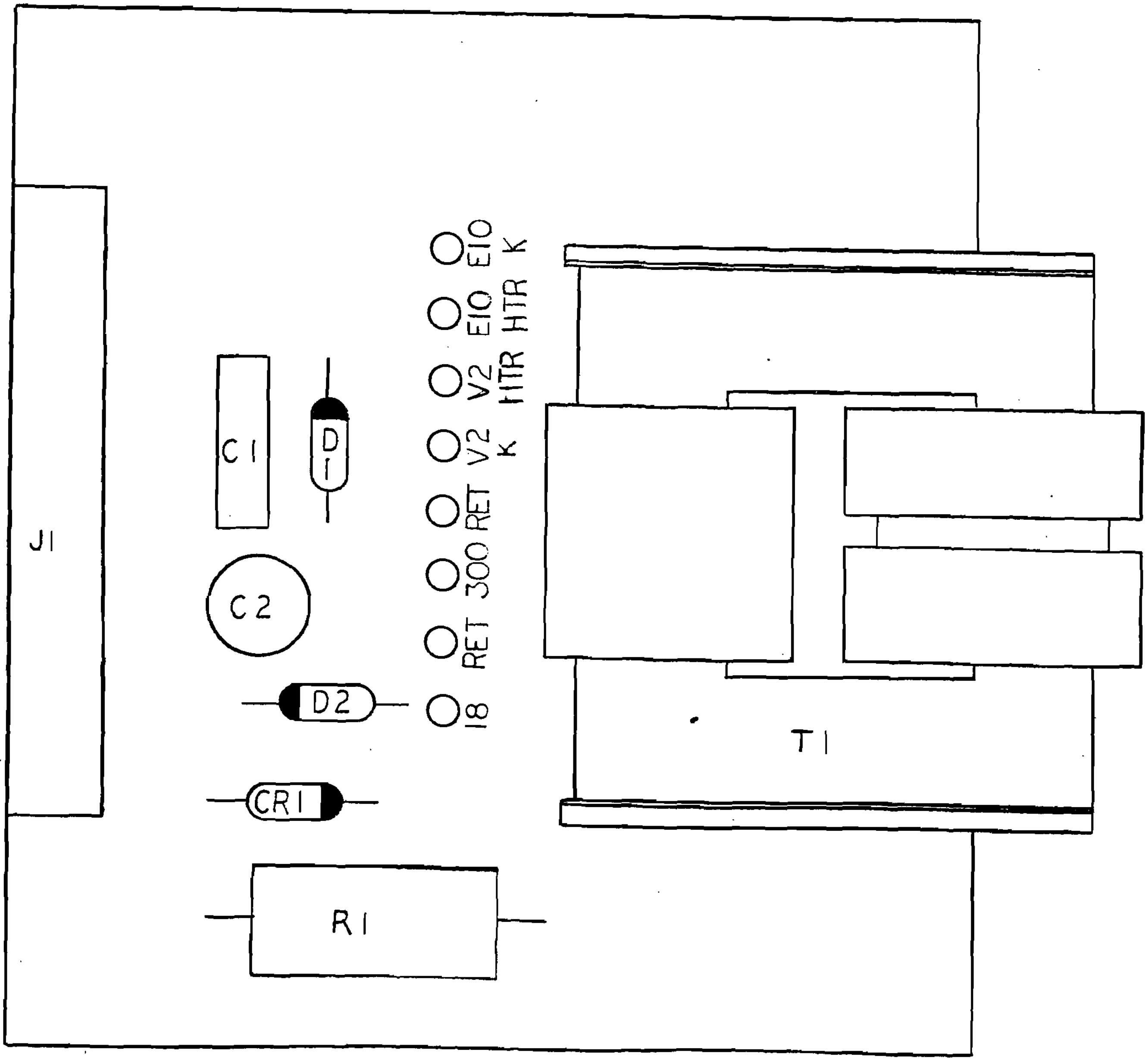


Figure A-15. Parts location diagram for isolation transformer supply T1.

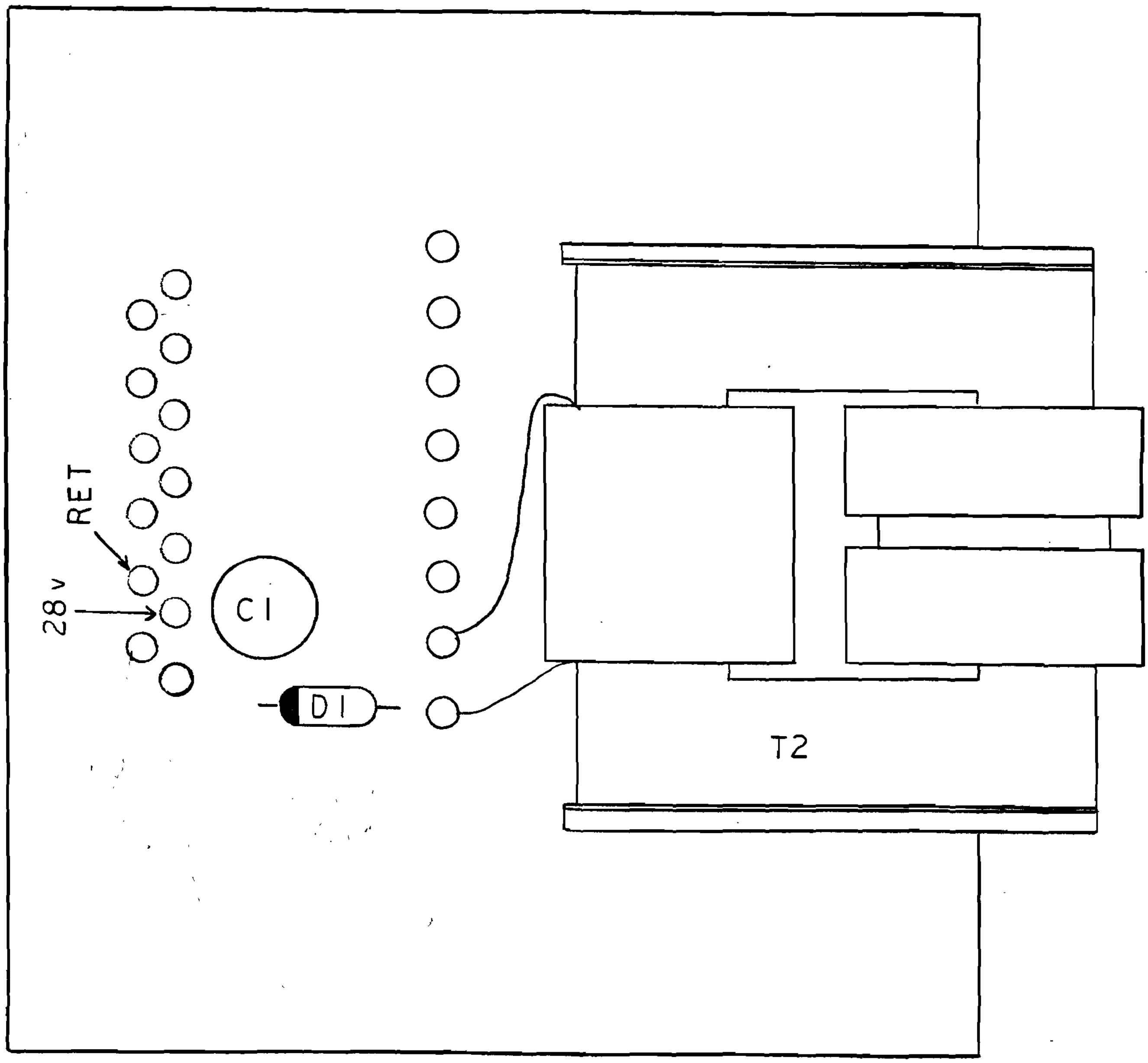


Figure A-16. Parts location diagram for isolation transformer supply T2.

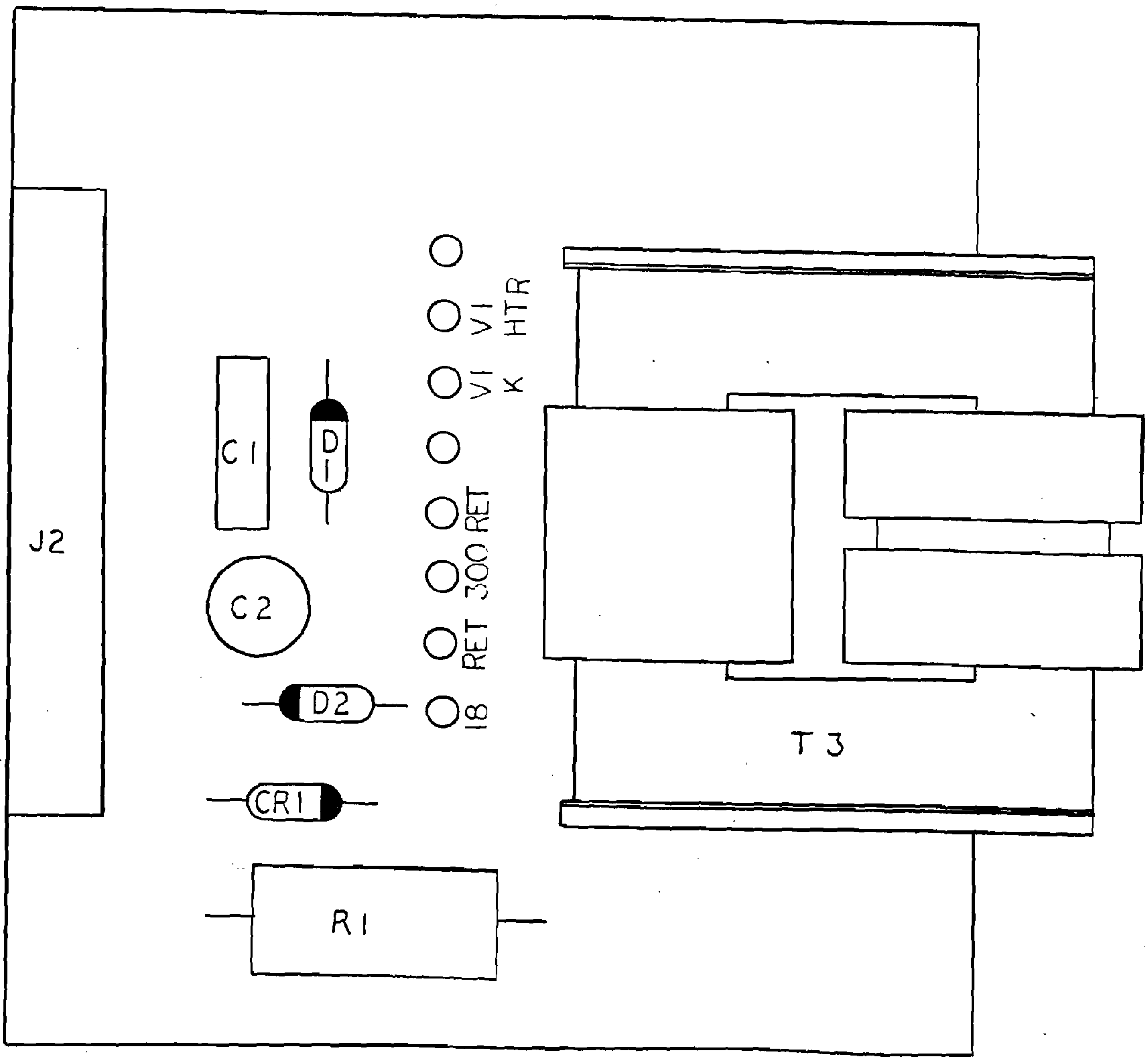


Figure A-17. Parts location diagram for isolation transformer supply T3.

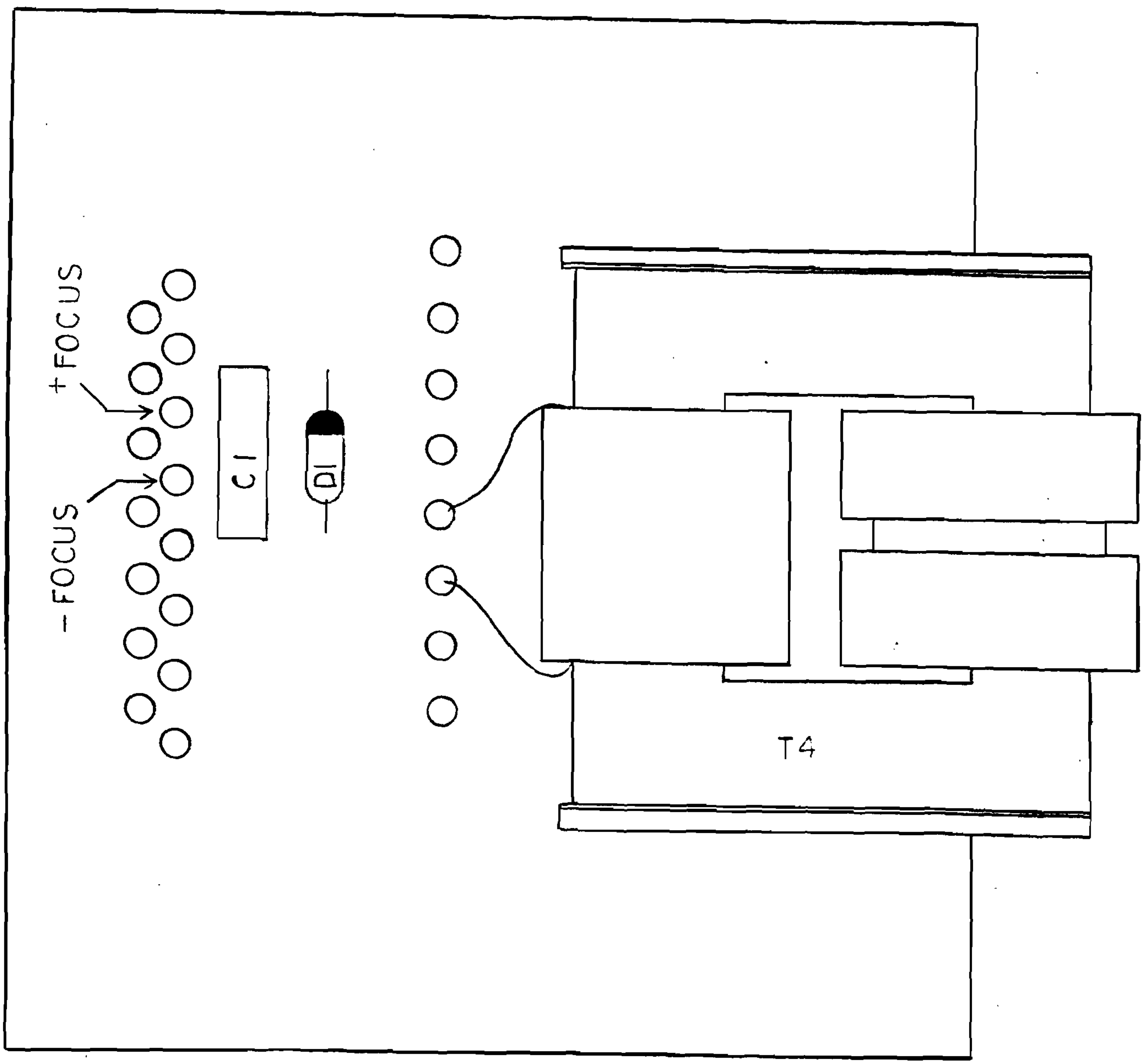


Figure A-18. Parts location diagram for isolation transformer supply T4.

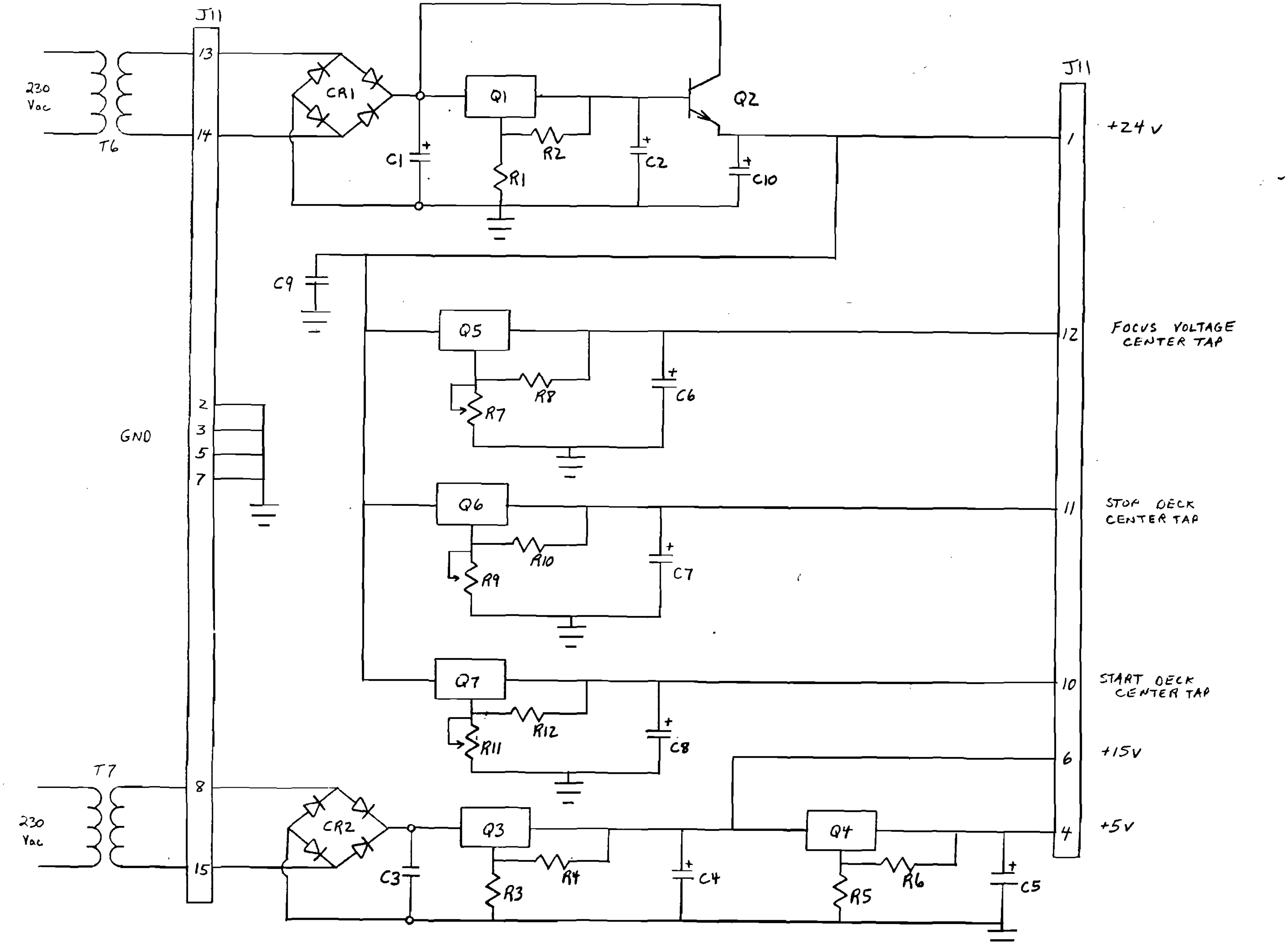


Figure A-19. Schematic diagram of Low Voltage Power Supply.

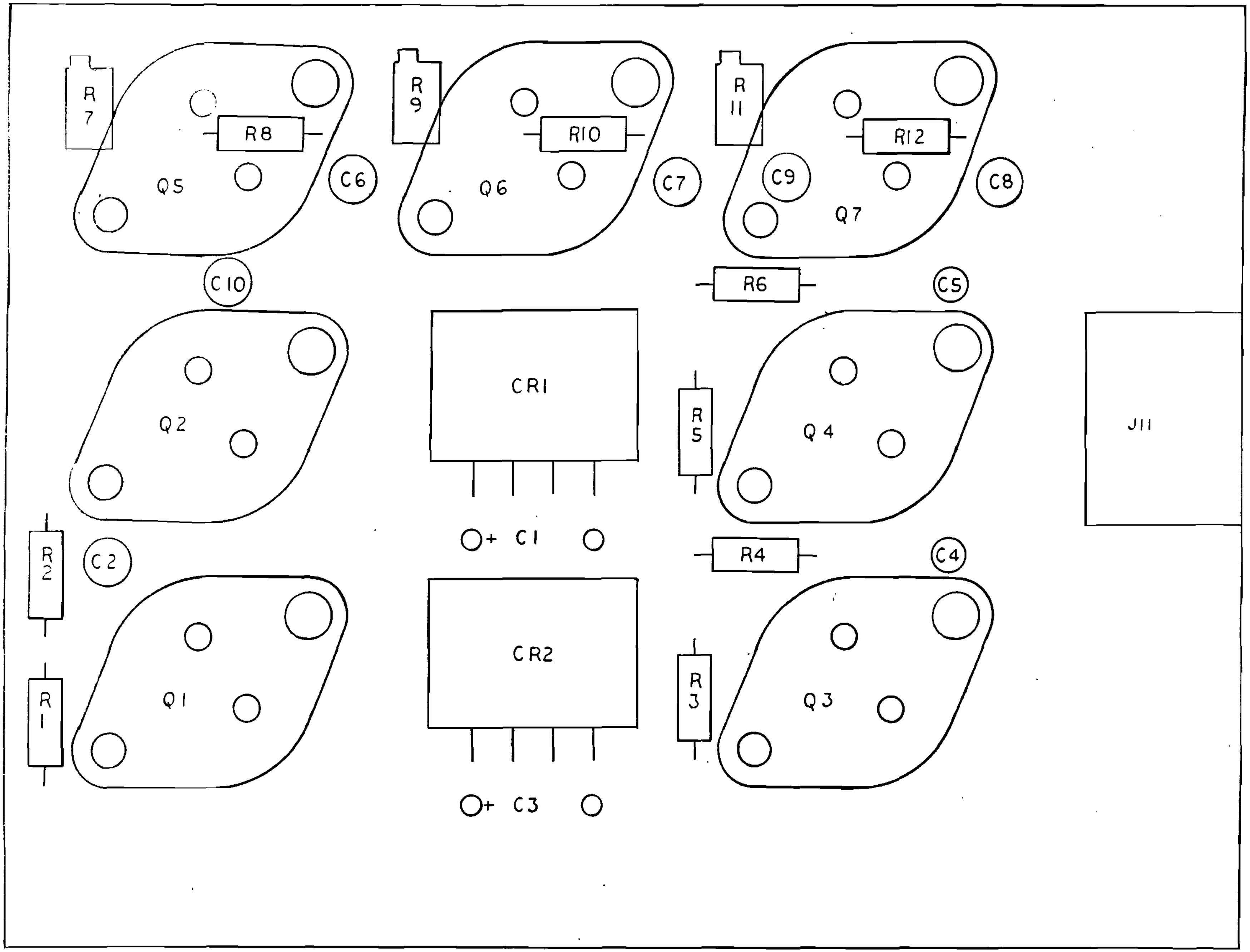


Figure A-20. Parts location diagram of Low Voltage Power Supply.

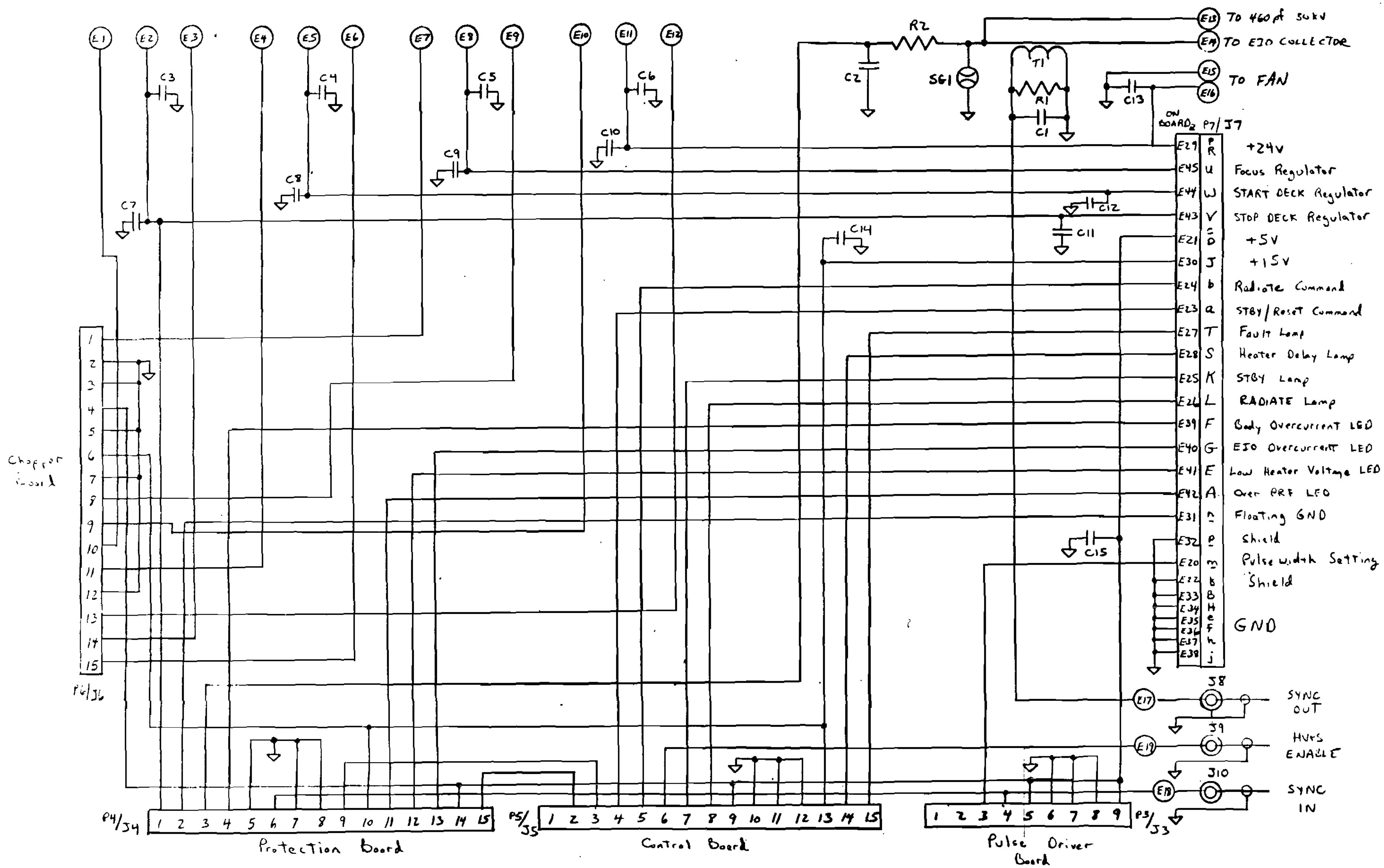


Figure A-21. Schematic diagram of Interconnect Board.

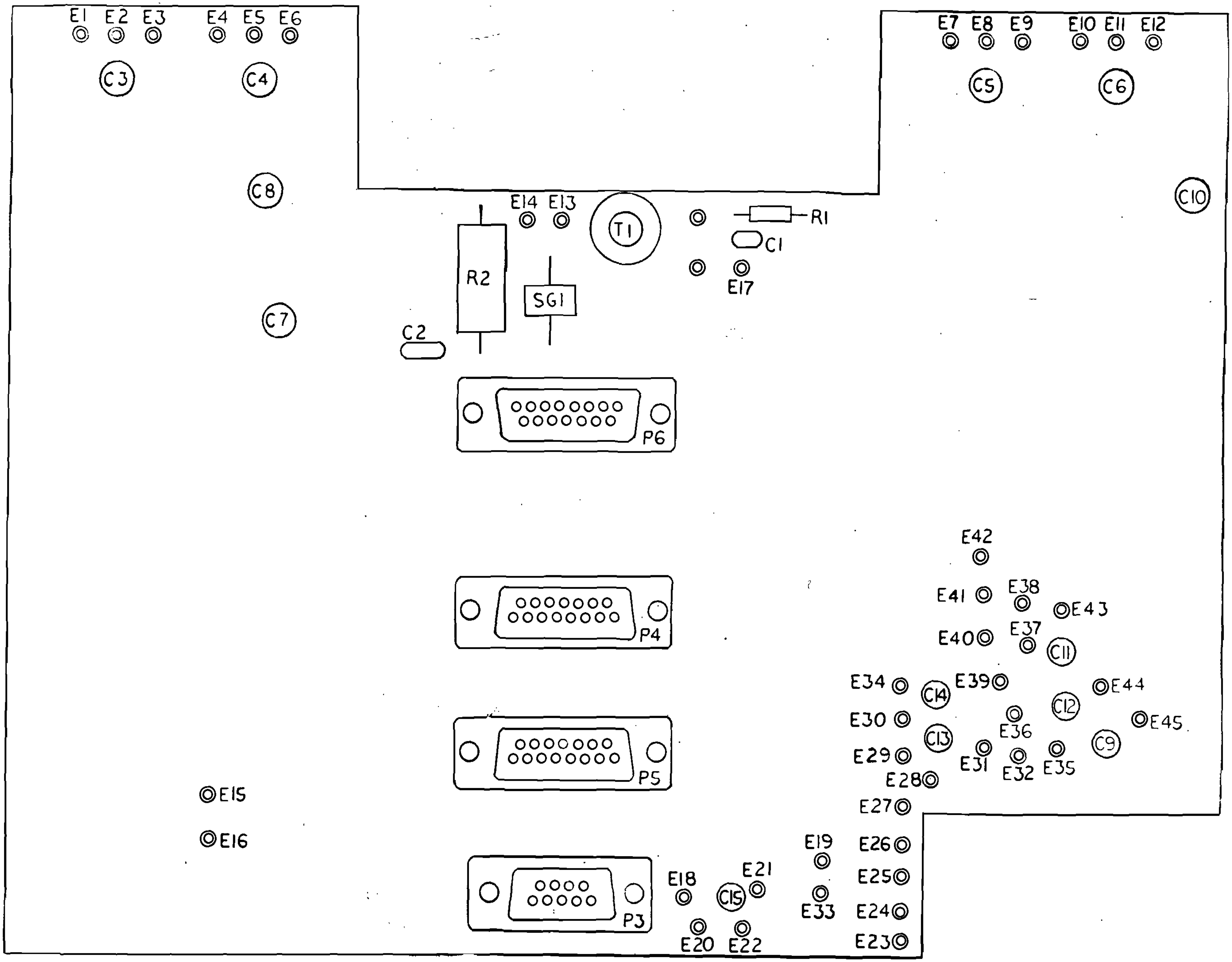


Figure A-22. Parts location diagram for Interconnect Board.

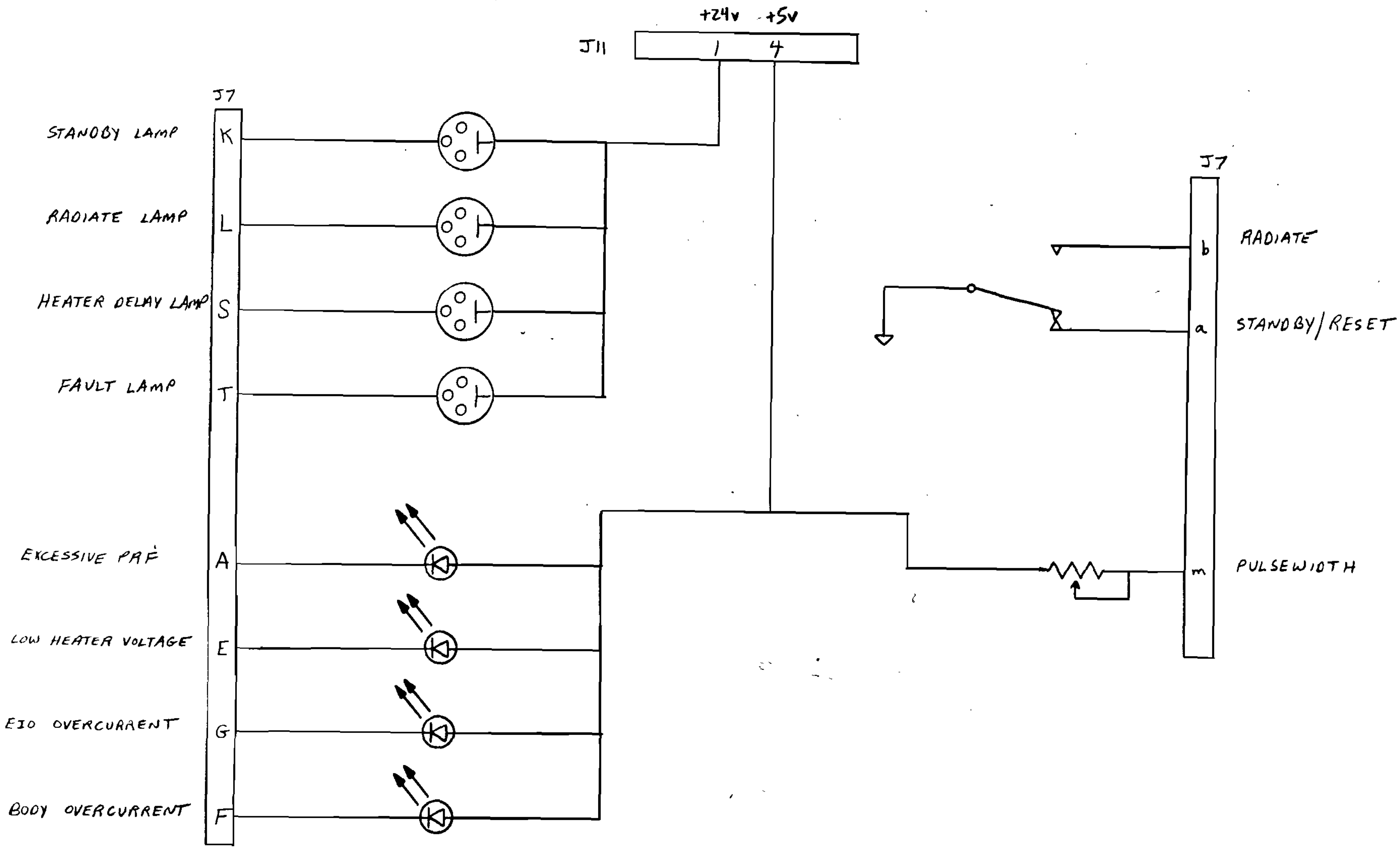


Figure A-23. Schematic diagram of wiring modifications made to Spellman Power Supply front panel.

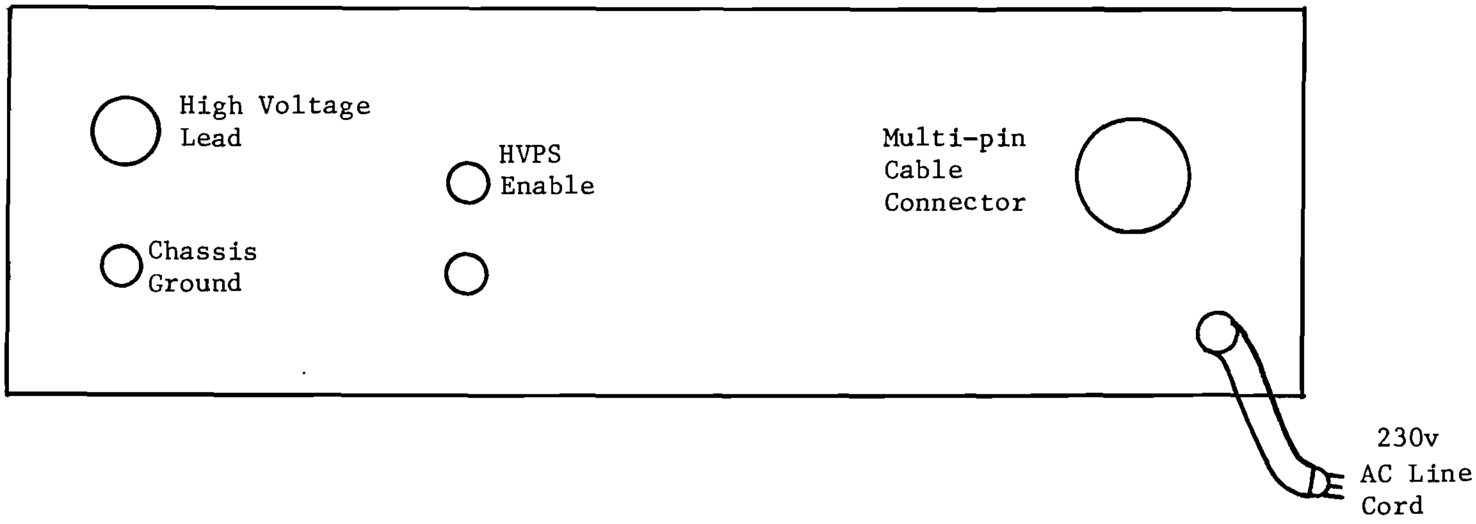


Figure 24. View of back panel of power supply showing connector designations.

TABLE A-1. CABLE PIN ASSIGNMENTS FOR CABLE BETWEEN MODULATOR AND POWER SUPPLY

Pin #	Signal	Destination in Power Supply	Destination in Modulator
A	Excessive PRF	Cathode of Excessive PRF LED	Protection: J4-11
B	GND		
C,D	+5 V	LVPS: J11-4 Front Panel LED's Pulsewidth Potentiometer	Pulse Driver J3-5,9 Control: J5-9 Protection: J4-14 Chopper: J6-4
E	Low Heater Voltage	Cathode of Low Heater Voltage LED	Protection: J4-12
F	Body Overcurrent	Cathode of Body Overcurrent LED	Protection: J4-4
G	EIO Overcurrent	Cathode of EIO Overcurrent LED	Protection: J4-13
H	GND		
J	+15 V		Control: J5-13 Protection: J4-10 Chopper: J6-6
K	STBY LAMP	Low Side of STANDBY LAMP	Control: J5-7
L	RADIATE LAMP	Low Side of RADIATE LAMP	Control: J5-8
P	N/C		
R	N/C		
M,N	+24 V	LVPS: J11-1 Front Panel Lamps	Interconnect: E-29
S	Heater Delay Lamp	Low Side of Heater Delay Lamp	Control: J5-14
T	Fault Lamp	Low Side of Fault Lamp	Control: J5-15
U	Focus Regulator Voltage	LVPS: J11-12	Interconnect: E45
V	Stop Deck Regulator Voltage	LVPS: J11-11	Protection: J4-1 Interconnect: E43
W	Start Deck Regulator Voltage	LVPS: J11-10	Interconnect: E44
X	N/C		
Z	N/C		

TABLE A-1. CABLE PIN ASSIGNMENTS FOR CABLE BETWEEN MODULATOR AND POWER SUPPLY (CONTINUED)

Pin #	Signal	Destination in Power Supply	Destination in Modulator
a	STBY/RESET Command	Front Panel Switch	Control: J5-4
b	Radiate Command	Front Panel Switch	Control: J5-5
c	Spare		
d	Spare		
e	GND		
f	GND		
g	N/C		
h	GND		
j	GND		
k	Shield	GND	GND
m	Pulsewidth Setting	Front Panel Potentiometer	Pulse Driver: J3-3
n	Floating Ground	Back Panel	Protection: J4-2
p	Shield	GND	GND
r	Spare		
s	Spare		

APPENDIX B

PARTS LISTS

PARTS LIST

PARTS LIST	LIST TITLE: Pulse Driver	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			49.9Ω 1%	R1	
			7.5kΩ 1%	R2	
			2 kΩ 1%	R3	
			3.9kΩ	R4,R5	
			100Ω 1/8w 1%	R6,R7	
			2.61kΩ 1%	R8	
			100Ω 1/8w 1%	R9	
			4.99kΩ 1%	R10	
			47.5Ω 1%	R11-R13	
			39 pf	C1	
			.22 μf	C2	
			47 pf	C3	
			.001 μf	C4	
			.22 μf	C5	
			.001 μf	C6	
			.22 μf	C7	
			47 pf	C8	
			120 pf	C9	
			.22 μf	C10-C13	
			10 μf 25v tantalum	C14	
			.22 μf	C15	
			270 pf	C16	
			.01 μf	C17	
	1N4733A		5.1 v zener	CR1	
	DM74LS221		Dual one-shot	U1,U7	
	DS0026		MOS Clock Driver	U2,U5	
	PE9825		Delay Line	U3,U6,U8	
	74S02		Quad NOR Gate	U4	
	75451		NAND Driver	U9	
	75452		AND Driver	U10	
	HFBR-0500		Optical Transmitter	U11-U13	
	DAE15PA		15 pin D connector	J3	

PARTS LIST

LIST TITLE:	CONTRACT NO:	DATE:
Modulator Start Deck A2A		1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
	75451		NAND Driver	U1,U2	
	DS0026		MOS Clock Driver	U3,U4	
	IVN6000CNT		MOSFET Transistor	Q1-Q3	
	8847A		Planar Triode	V1	
	1N5378		100v 5watt zener	CR1	
	1N5388		200v 5watt zener	CR2	
	1N5371		60 v 5watt zener	CR3	
	1N4937		Diode	D1	
			.22 µf	C1,C2	
			100 pf	C3-C5	
			.22 µf	C6,C7	
			390 pf	C8-C11	
			.15 µf 400v	C12	
			.22µf 250v	C13	
			.047µf 400v	C14	
			20Ω	R1-R3	
			3.9kΩ	R4-R6	
			10Ω	R7,R9R11	
			150Ω	R8,R10R12	
			390Ω 2watt	R13	
			1.5kΩ 2watt	R14	
			330Ω	R15	
			Inductor choke, 100 µh	L1,L2	
			Toroid inductor,3 turns bif.	L3	
			planar triode heatsink		
		3	mica insulator		for Q1-Q3
	Elco 8129		15 pin connector	J2	

PARTS LIST

LIST TITLE: Modulator Start Deck A2B

CONTRACT NO:

DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
	HFBR-0500		Optical Receiver	U1,U2	
	74S20		Dual NAND Gate	U3	
	75451		NAND Driver	U4	
			100 μh choke	L1	
			200Ω	R1	
			.1 μf	C1-C3	

PARTS LIST	LIST TITLE: Modulator Stop Deck	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF / NOTES
	DS0026		MOS Clock Driver	U1	
	HFBR-0500		Optical Receiver	U2	
	IVN6000CNT		MOSFET Transistor	Q1,Q2	
	8847A		Planar Triode	V2	
			100 μh choke	L1,L2	
			Toroid inductor,16 turns bif.	L3	
			1 kΩ	R1	
			3.9kΩ	R2,R3	
			10Ω	R4,R6	
			1kΩ	R5,R7	
			430Ω	R8	
			4.3kΩ	R9	
			1kΩ ½watt	R10	
			30kΩ 10 watt	R11	Caddock
	1N5378		100v 5watt zener	CR1	
	1N5388		200v 5watt zener	CR2	
	1N5371		60 v 5watt zener	CR3	
	1N4937		Diode Rectifier	D1	
			.22 μf	C1,C4	
			1000 pf	C2,C3	
			.005 μf 1kv	C5	
			.15 μf 400v	C6,C7	
			.022 μf	C8	
			.01 μf	C9	
	UBT4.0		Spark Gap 4kv	SG1	
			planar triode heatsink		
			mica insulator		for Q1,Q2
	Elco 8129		15 pin connector	J1	

PARTS LIST

LIST TITLE:	CONTRACT NO:	DATE:
Protection Circuit		4/1/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF / NOTES
			10 kΩ pot	R1	
			2.0 kΩ 1%	R2	
			499Ω 1%	R3	
			5.11 kΩ 1%	R4	
			17.4 kΩ 1%	R5	
			10.0 kΩ 1%	R6	
			20Ω ½ watt	R7	
			15kΩ 1%	R8	
			5.6kΩ	R9	
			300Ω 1%	R10	
			953Ω 1%	R11	
			27.4kΩ 1%	R12	
			280kΩ 1%	R13	
			18.2kΩ 1%	R14	
			40.2kΩ 1%	R15	
		4	3.9kΩ	R16-R19	
		4	51Ω	R20-R23	
			3010Ω 1%	R24	
			100 µh	L1	
	1N914		diode	D1,D2	
	1N4730		3.9 volt zener	CR1	
	1N4733	2	5.1 volt zener	CR2,CR3	
		5	.22 µf	C1,C3,C5,C9,C10	
			1200 pf polystyrene	C2	
			22 µf 25 v tantalum	C4	
		2	1 µf 50 v tantalum	C6,C13	
		2	4.7 µf 25v tantalum	C7,C8	
		2	.01 µf	C11,C12	
		4	.1 µf	C14-C17	
	74121		One-shot	U1	
	LM339		Quad Comparator	U2	
	7406		Hex Inverter	U4	
	7475		Quad D Latch	U5	
	7421		Dual 4-input AND Gate	U6	
	DAE15PA		15 pin D connector	J4	

PARTS LIST	LIST TITLE: Control Circuit	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			270Ω 1 watt	R1	
			51kΩ	R2	
			18kΩ	R3	
			620kΩ	R4	
			3.9kΩ	R5	
			10MΩ	R6	
			1kΩ	R7,R9	
			510kΩ	R8	
		4	68Ω 1 watt	R10,R11,	R13,R14
		3	2.2kΩ	R12.R15,	R16
	1N4733A		5.1 volt 1watt zener	CR1	
			.1 μf	C1,C2	
			.001 μf	C3	
			10 μf 25v tantalum	C4,C6	
		8	.1 μf	C5,C7-C13	
			.01 μf	C14	
			.22 μf	C15	
			1 μf	C16	
	LM339		Quad Comparator	U1	
	7408		Quad AND Gate	U2	
	LM122H		Precision Timer	U3,U4	
	7486		Quad XOR Gate	U5	
	7404		HEX Inveter	U6	
	74S74		Dual D Flip-Flop	U7	
	DS3611N		Dual Peripheral Driver	U8,U9	
	7406		Hex Inverter/Open Coll. output	U10	
	DAE15PA		15 pin D connector	J5	

PARTS LIST	LIST TITLE: Chopper Circuit	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			10kΩ	R1	
			15Ω	R2,R4	
			10kΩ	R3,R5	
			.1 µf	C1,C2	
			2200 pf	C3	
			.1 µf	C4,C5	
			.22 µf	C6,C9	
			.1 µf	C7,C8	
			22 µf 25volt tantalum	C10,C11	
	1N5375	8	82 volt 5watt zener	CR1-CR8	
	IRF 520	8	100volt,5amp HEXFET	Q1-Q8	
	SG1525A		Pulse-width Modulator	U1	
	DS0026		MOS Clock Driver	U2,U3	
	DAE15PA		15 pin D connector	J6	

PARTS LIST

LIST TITLE: Stop Deck Floating Power Supply	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			Transformer	T1	
	F740-1-05		Ferramic "U" core		
			Primary: 14 turns of #25awg		
			Bifilar winding		
			Secondaries:		
			(300v) 310 turns, #30awg		
			(18v) 18 turns, #28awg		
		2	(6.3v) 7 turns, #24awg		
			Primary on plexiglass spindle		
	MR818		Diode Rectifier	D1	
	1N4937		Diode Rectifier	D2	
	1N4733		5.1v 1watt zener	CR1	
			270Ω 1 watt	R1	
			.047 µf 400volt	C1	
			15 µf 35 volt	C2	
	Elco 8129		15 pin connector	J1	

PARTS LIST

LIST TITLE: 28v to -3kv Floating power supply	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			Transformer	T2	
	F740-1-05		Ferramic "U" core		
			Primary: 16 turns of #22awg		
			bifilar on plexiglass		
			spindle		
			Secondary: 22 turns of #25		
			awg		
	MR856		Diode Rectifier	D1	
			22 μf, 35volt tantalum	C1	

PARTS LIST

LIST TITLE: Start Deck Floating Power Supply

CONTRACT NO:

DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			Transformer	T3	
	F740-1-05		Ferramic "U" Core		
			Primary: 16 turns of #25awg		
			bifilar on plexiglass		
			spindle		
			Secondaries:		
			(300v) 290 turns, #30awg		
			(18v) 18 turns, #30awg		
			(6.0v) 6 turns, #25awg		
	MR818		Diode Rectifier	D1	
	1N4937		Diode Rectifier	D2	
	1N4733		5.1volt 1 watt zener	CR1	
			150Ω 2 watt	R1	
			.047 µf 400volt	C1	
			15 µf 35 volt tantalum	C2	
	Elco 8129		15 pin connector	J2	

PARTS LIST

LIST TITLE: Focus Volt. Floating Power Supply	CONTRACT NO:	DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			Transformer	T4	
	F740-1-05		Ferramic "U" Core		
			Primary: 14 turns of #25awg		
			bifilar on plexiglass		
			spindle		
			Secondary: 200 turns of		
			#28 awg		
	MR818		Diode Rectifier	D1	
			.22 μf 250 volt	C1	

PARTS LIST

LIST TITLE: Low Voltage Power Supply

CONTRACT NO:

DATE: 1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			4530Ω 1%	R1	
		6	243Ω 1%	R2,R4,R6,	R8,R10,R12
			2740Ω 1%	R3	
			732Ω 1%	R5	
		3	10kΩ pot	R7,R9,R11	
		2	2400 μf, 50 volt	C1,C3	
		5	15 μf, 35 volt	C2,C6-C8,	C10
			22 μf, 25 volt	C4,C5	
			22 μf, 35 volt	C9	
	MDA970A1		4 amp,50 v bridge rectifier	CR1,CR2	
	LM317K	3	1.5amp Voltage Reg.	Q1,Q3,Q4	
	2N6338		Power NPN Transistor	Q2	
	LM350K	3	3 amp Voltage Reg.	Q5,Q6,Q7	
	47-1115S		15 pin D connector	J11	
	Triad F-214U		230v to 24v 4amp transformer	T6	
	Triad F-107Z		230v to 24v 2amp transformer	T7	

PARTS LIST

LIST TITLE:	CONTRACT NO:	DATE:
Interconnect Board		1/10/84

FIND NO.	PART NUMBER	QTY RQD	DESCRIPTION	REF DESIG.	PAGE OF NOTES
			120	R1	
			100k 2 watt	R2	
			1kv spark gap	SG1	
			27 pf	C1	
			.1 µf	C2	
		11	22 µf, 35 volt	C3-C14	
			22 µf, 25 volt	C15	
			25 turns on BBR7725 toroid	T1	
	DEE9SU		9 pin D connector	P3	
	DAE15SU	3	15 pin D connector	P4-P6	

APPENDIX C

MANUFACTURER'S SPECIFICATION SHEETS

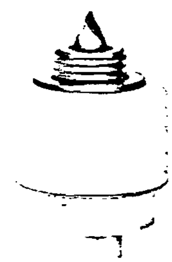
8847
8847A

TECHNICAL DATA

HIGH-MU PLANAR TRIODES

The 8847 and 8847A are miniature, ceramic/metal, rugged planar triodes for advanced airborne and space applications up to 3.5 GHz.

The 8847A is identical to the 8847 in all respects except that the required heater power is reduced by 25%. The tube should be used where input power consumption and heat dissipation are of major concern.



Either tube may be used as an amplifier, oscillator, or frequency multiplier in the CW, grid- or plate-pulsed mode, as well as a modulator or regulator tube. In addition to low interelectrode capacitances, high transconductance and amplification factor, the 8847 and 8847A have an anode designed to enhance frequency stability and an arc-resistant cathode, both assuring stable, reliable and long-life operation under adverse conditions.

The 8847 and 8847A are supplied without radiator and may be conduction, convection, heat sink, or liquid cooled. Radiators for forced-air cooling permitting an anode dissipation up to 150 watts, can be furnished on separate order.

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Cathode: Oxide Coated, Unipotential		
Heater: Voltage	6.3 ± 0.3	V
8847 Current, at 6.3 volts	1.30	A
8847A Current, at 6.0 volts	0.95	A
Transconductance (Average):		
I_b = 160 mA (200 mA/cm^2)	38	mmhos
Amplification Factor (Average):	75	
Direct Interelectrode Capacitances (Grounded Cathode)[2]		
Grid-Cathode	9.5	pF
Plate-Cathode	0.06	pF
Grid-Plate	1.40	pF
Cut-off Bias[3]	-30	V max.

1. Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment.

2. Capacitance values for a cold tube as measured in a special shielded fixture. When the cathode is heated to the proper temperature, the grid-cathode capacitance will increase from the cold value by approximately 1 pF due to thermal expansion of the cathode.

3. Measured with one milliampere plate current and a plate voltage of 1 kVdc.

MECHANICAL

Maximum Overall Dimensions:	
Length	1.370 in; 34.75 mm
Diameter	0.785 in; 19.94 mm
Net Weight	0.56 oz; 16.0 gm
Operating Position	Any
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Anode Core	250°C
Cooling	Conduction, convection, forced-air[1] or liquid
Terminals	Coaxial, special

ENVIRONMENTAL

Shock, 11 ms, non-operating	60 G
Vibration, operating, all axes 55 to 500 Hz	10 G
Altitude, max (in suitable designed circuit)	70,000 ft.

CW RF POWER AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS/ABSOLUTE VALUES

DC PLATE VOLTAGE	2500	VOLTS
DC GRID VOLTAGE	-150	VOLTS
INSTANTANEOUS PEAK GRID-CATHODE VOLTAGE		
Grid negative to cathode	-400	VOLTS
Grid positive to cathode	30	VOLTS
DC PLATE CURRENT	250	MILLIAMPERES
DC GRID CURRENT	45	MILLIAMPERES
PLATE DISSIPATION[1]	150	WATTS
GRID DISSIPATION	1.5	WATTS
FREQUENCY	3.0	GIGAHERTZ

1. Using one of the EIMAC radiators shown on the cooling curves.

2. For application requiring longer pulse duration and/or higher duty cycle consult the nearest Varian Electron Tube and Devices Field Office, or the Product Manager, Eimac-Division of Varian, Salt Lake City, Utah.

GRID PULSED OR PLATE PULSED AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS/ABSOLUTE VALUES

DC PLATE VOLTAGE(GRID PULSED)	3000	VOLTS
PEAK PULSE PLATE VOLTAGE (PLATE PULSED)	3500	VOLTS
DC GRID VOLTAGE	-150	VOLTS
INSTANTANEOUS PEAK GRID-CATHODE VOLTAGE		
Grid negative to cathode	-700	VOLTS
Grid positive to cathode	175	VOLTS
PULSE PLATE CURRENT	5.0	AMPERES
PUSLE GRID CURRENT	2.5	AMPERES
PLATE DISSIPATION[1]	150	WATTS
GRID DISSIPATION	1.5	WATTS
FREQUENCY	3.5	GIGAHERTZ
PULSE DURATION[2]	6	μsec
DUTY FACTOR[2]	.0033	

REPRESENTATIVE OPERATION

Grid-Pulsed rf Power Oscillator (1.6 GHz)

DC Plate Voltage	3000	Vdc
Peak Plate Current	3.0	a
DC Grid Voltage (Approx.)	-90	V
Peak Grid Current	1.0	a
Filament Voltage	6.3	V
Useful Power Output (Approx.)	3000	w
Bandwidth (1db)	40	MHz
Plate Efficiency	33%	

PULSE MODULATOR OR PULSE AMPLIFIER SERVICE

MAXIMUM RATINGS/ABSOLUTE VALUES

DC PLATE VOLTAGE	3500	VOLTS
PEAK PLATE VOLTAGE	4000	VOLTS
DC GRID VOLTAGE	-150	VOLTS
INSTANTANEOUS PEAK GRID-CATHODE VOLTAGE		
Grid negative to cathode	-750	VOLTS
Grid positive to cathode	150	VOLTS
PULSE CATHODE CURRENT	7.5	AMPERES
DC PLATE CURRENT	150	MILLIAMPERES
PLATE DISSIPATION[1]	150	WATTS
GRID DISSIPATION	1.5	WATTS
PULSE DURATION	6	µs
DUTY FACTOR	.0033	
CUT-OFF MU	60	

1. Using one of the EIMAC radiators shown on the cooling curves.
2. For application requiring longer pulse duration and/or higher duty cycle consult the nearest Varian Electron Tube and Device Field Office, or the Product Manager Eimac-Division of Varian, Salt Lake City, Utah.

RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Heater current at 6.3 volts (8847)	1.20	1.40	A
Heater current at 6.0 volts (8847A)	0.85	1.05	A
Cathode Heating Time	60	---	sec.
Interelectrode Capacitances[1] (grounded cathode connection)			
Grid-Cathode	8.5	10.5	pF
Plate-Cathode	---	0.06	pF
Grid-Plate	1.2	1.6	pF

1. Capacitance values for a cold tube as measured in a special shielded fixture. When the cathode is heated to the proper temperature, the grid-cathode capacitance will increase from the cold value by approximately 1 pF due to thermal expansion of the cathode.

APPLICATION

COOLING - The 8847 and 8847A can be cooled by conduction, convection, forced-air or liquid cooling. The tubes are designed to permit high-temperature operation up to the limit indicated. However, if long life is the prime objective, tube terminal and seal temperatures should be kept well below 250°C. If forced-air cooling is provided, auxiliary air flow, apart from the air flowing through the radiator, should be provided to cool the tube envelope and other tube terminals. Some conduction cooling is always provided through the contact terminals. However, these terminals usually exhibit poor heat transfer, often having a temperature gradient across them as high as 50°C. Cooling curves are given for the three radiators which are suitable for use with the 8847 and 8847A.

For further details on cooling or other aspects of tube operation, refer to the "Application Notes for Planar Triodes" bulletin which can be obtained on request.

DIMENSIONAL DATA

DIM.	INCHES MIN.	INCHES MAX.	INCHES REF.	MILLIMETERS MIN.	MILLIMETERS MAX.	MILLIMETERS REF.
A	--	1.020	--	--	25.91	--
D	0.740	0.800	--	18.80	20.32	--
F	--	0.570	--	--	14.48	--
G	0.150	0.170	--	3.81	4.32	--
H	--	0.040	--	--	1.02	--
J	--	0.350	--	--	8.90	--
L	--	0.260	--	--	6.60	--
M	0.545	0.570	--	13.84	14.48	--
P	0.775	0.785	--	19.69	19.94	--
R	0.650	0.670	--	16.51	17.02	--
T	0.210	0.225	--	5.33	5.72	--
U	0.310	0.330	--	7.87	8.38	--
V	--	0.040	--	--	1.07	--
AB	0.590	0.740	--	14.99	18.80	--
AC	0.760	0.885	--	19.30	22.48	--
AD	0.800	0.975	--	20.32	24.77	--

NOTES:
1. REF. DIMENSIONS ARE FOR INFO. ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.

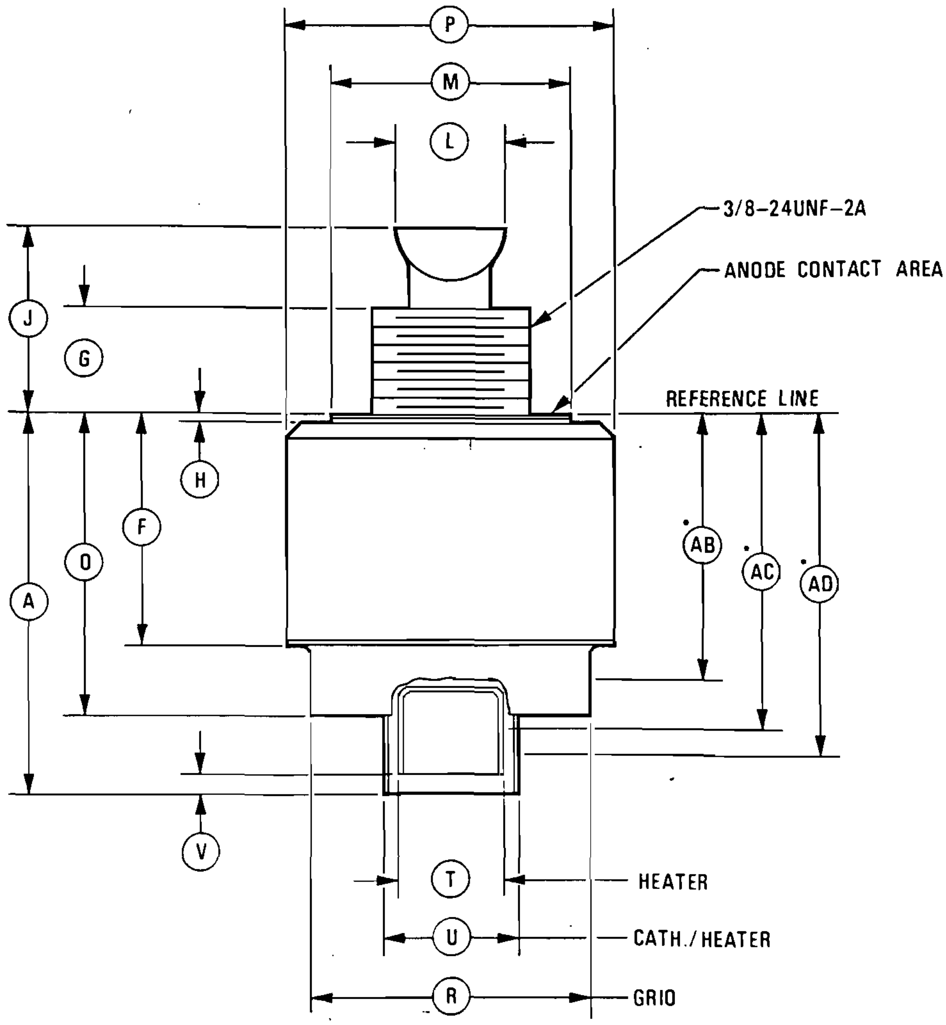
NOTES:

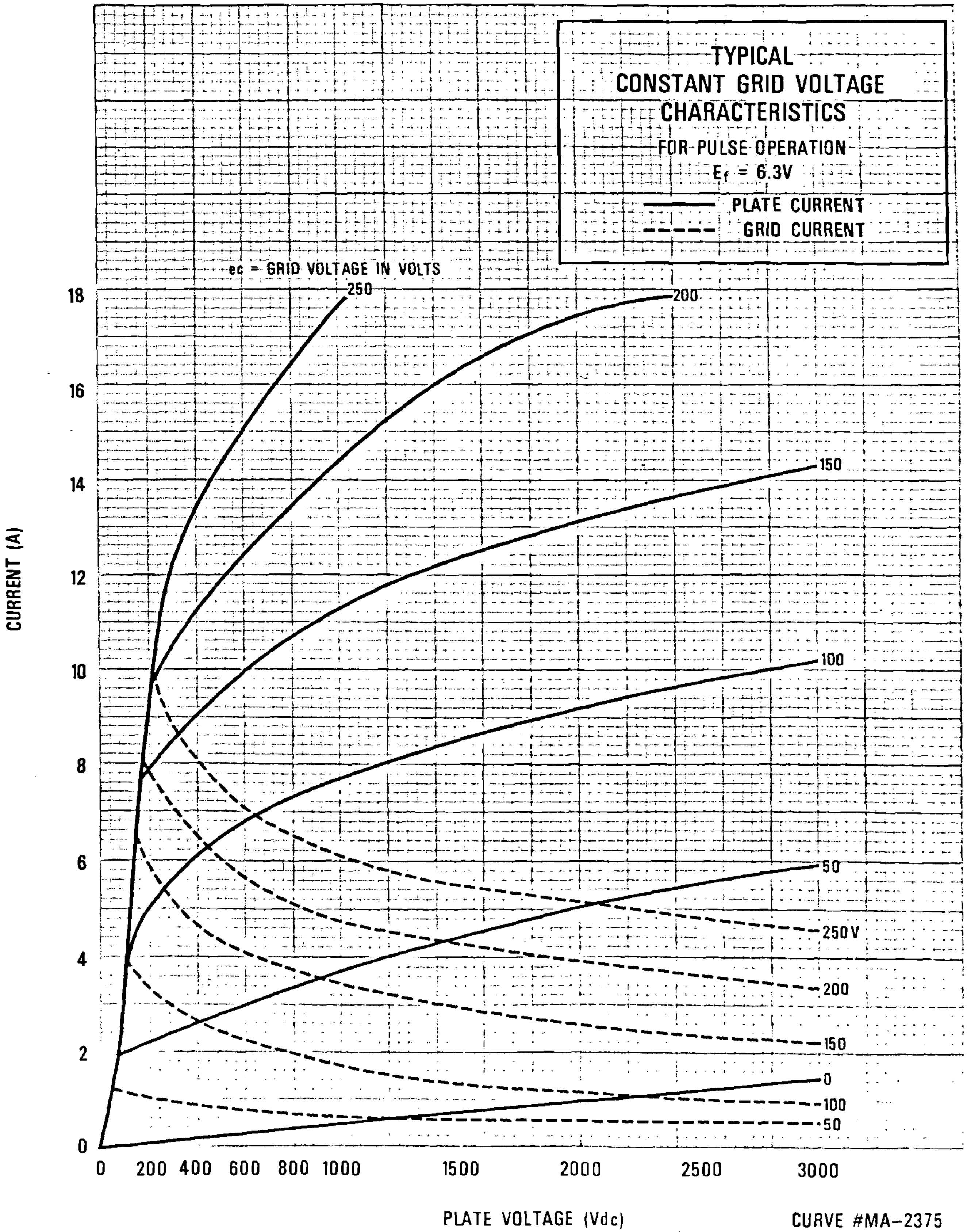
1. ANODE FLANGE IS ELECTRICAL CONTACT. STUD IS FOR HEAT TRANSFER.

2. (*) DISTANCE FROM REFERENCE SURFACE TO THE CENTER OF CONTACT AREA.

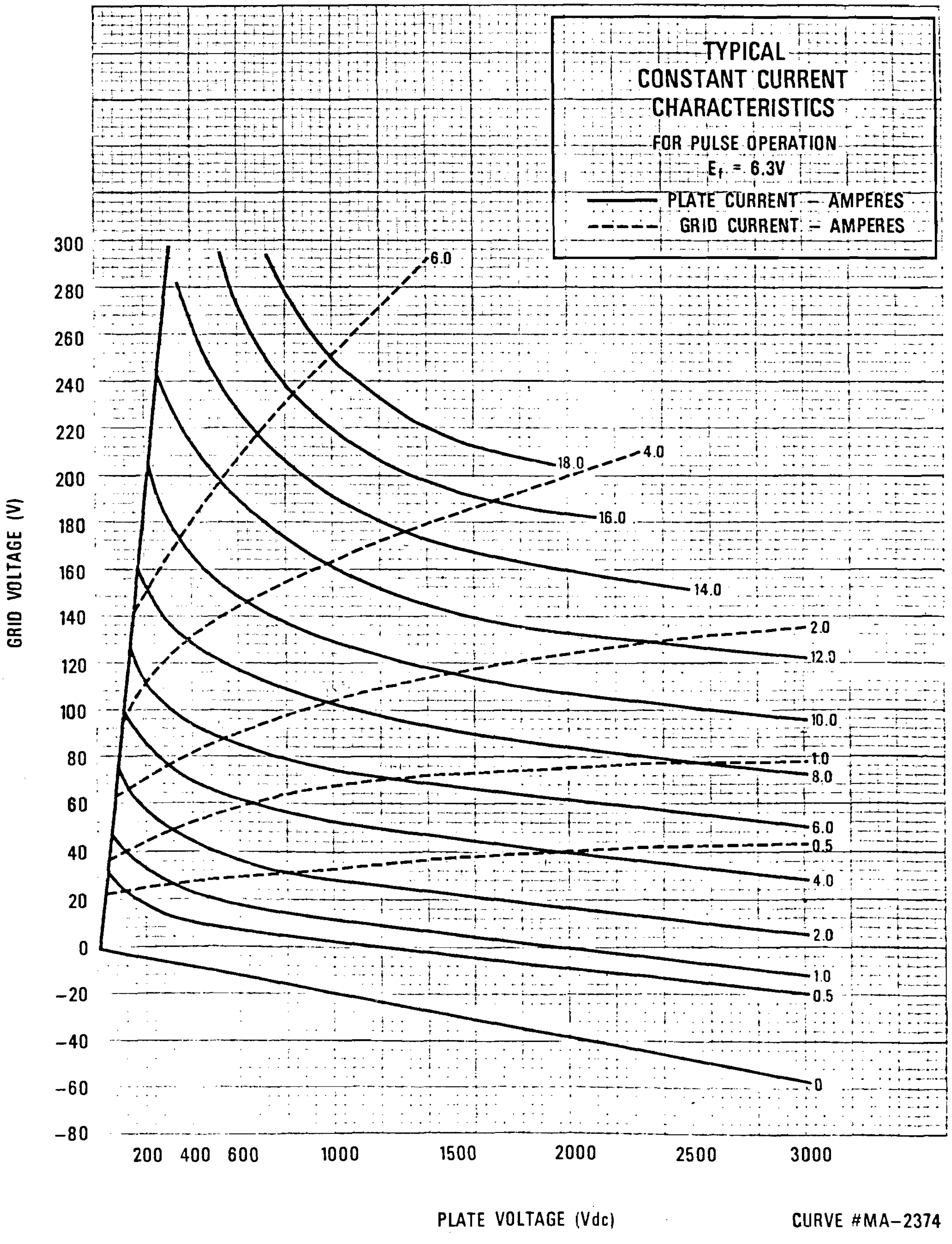
3. METRIC EQUIVALENTS ARE TO THE NEAREST .01 mm, ARE GIVEN FOR GENERAL INFORMATION ONLY, AND ARE BASED ON 1 INCH = 25.4 mm.

4. CONCENTRICITY BETWEEN GRID TERMINAL AND CATHODE/HEATER TERMINAL RESPECTIVELY TO THE ANODE STUD TO BE 0.020 TIR MAX. MEASUREMENT TO BE MADE WITH EIMAC GAGE JA-21685G WHICH MUST SEAT AGAINST THE ANODE FLANGE.

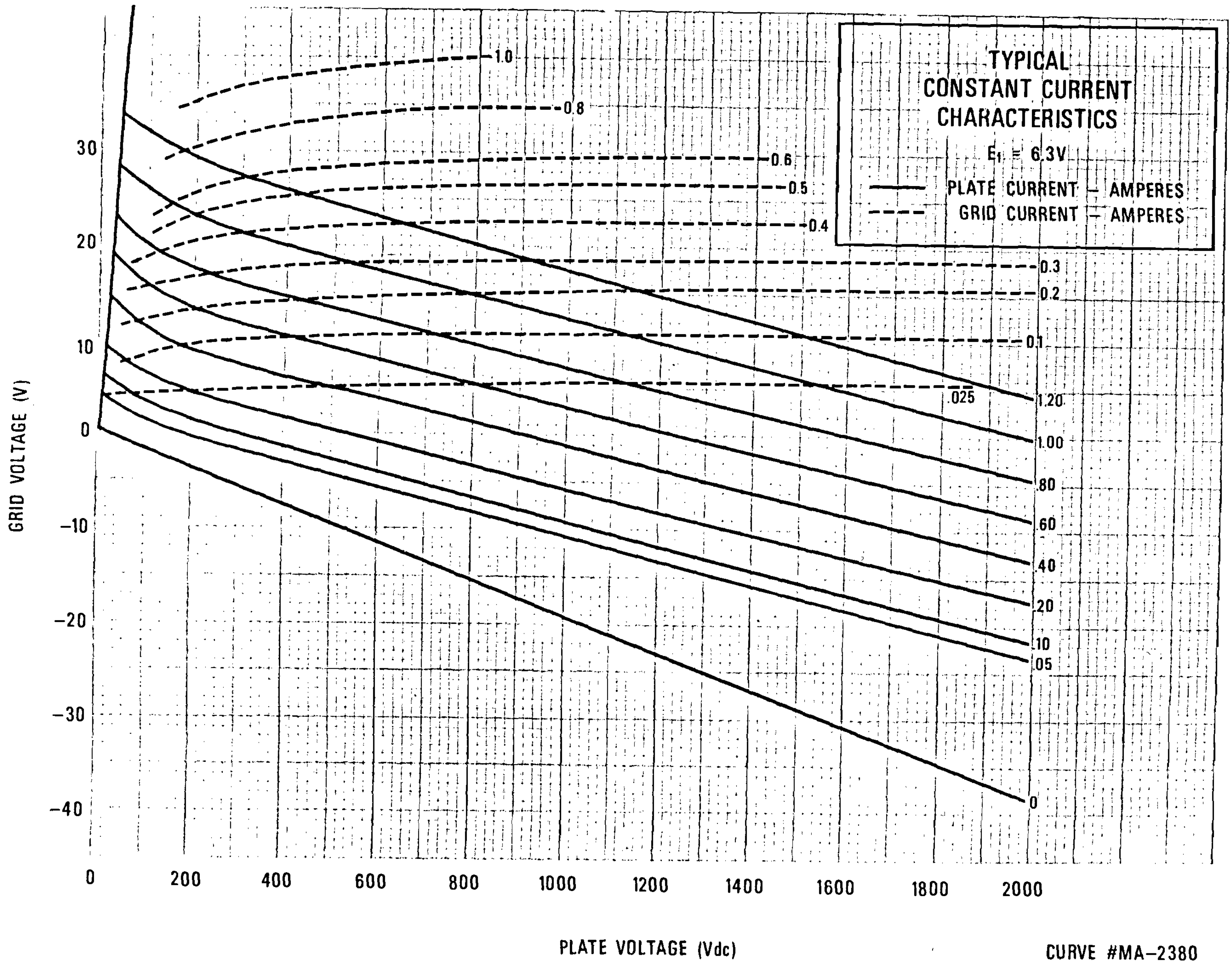




CURVE #MA-2375

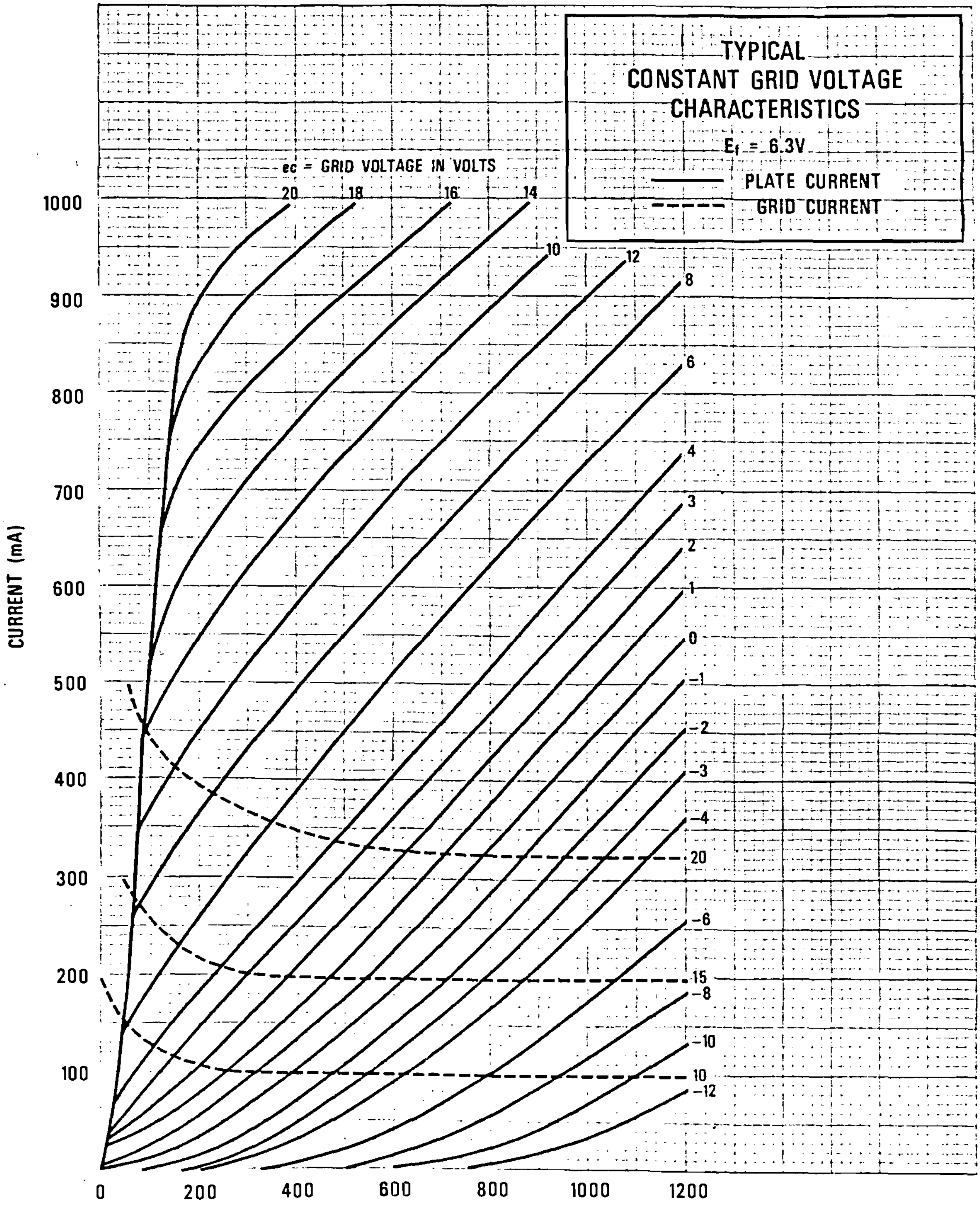


CURVE #MA–2374

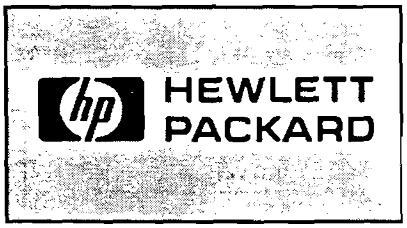


CURVE #MA-2380

8847/8847A



CURVE #MA–2379



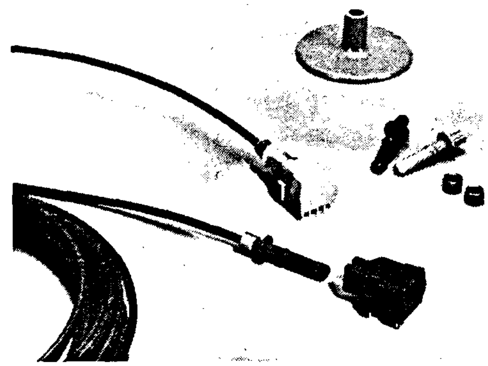
SNAP-IN FIBER OPTIC LINK

HFBR-0500 TO HFBR-4595

TECHNICAL DATA JANUARY 1983

Features

- LOW COST PLASTIC DUAL-IN-LINE PACKAGE
- SNAP-IN CONNECTOR
- 665 nm EMITTER OPTIMIZED FOR PLASTIC CABLE
- EASY FIELD TERMINATIONS
- SHIELDED RECEIVER FOR HIGH NOISE IMMUNITY
- OPERATION TO 22 METRES — GUARANTEED OVER TEMPERATURE
- DC TO 5 MBaud DATA RATE
- LSTTL/TTL COMPATIBLE OUTPUT LEVEL
- CHOICE OF INTERNAL PULL-UP OR OPEN COLLECTOR OUTPUT
- STANDARD OR SPECIAL LENGTH CABLES
- SINGLE +5V RECEIVER POWER SUPPLY
- COLOR CODED TRANSMITTER AND RECEIVER
- SIMPLEX AND ZIP CORD STYLE DUPLEX CABLE



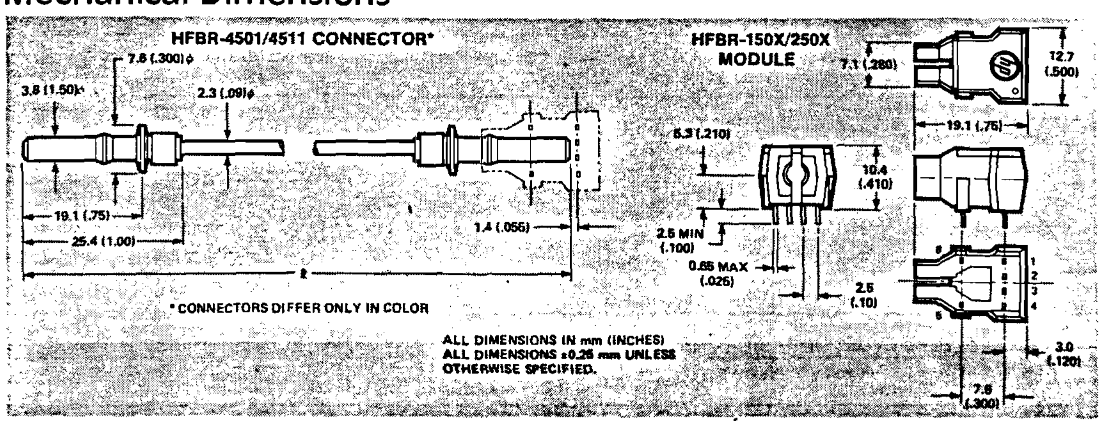
Applications

- EMC REGULATED SYSTEMS (FCC, VDE)
- INTER/INTRA-SYSTEM DATA LINK
- STATIC PROTECTION
- HIGH VOLTAGE ISOLATION
- MEDICAL EQUIPMENT
- SECURE DATA COMMUNICATIONS

Description

The HFBR-0500 series is a complete family of fiber optic link components for configuring low-cost, short distance digital data transmission links. These components are designed to mate with plastic snap-in connectors and low-cost plastic fiber cable. Link design is simplified by the logic compatible receivers and the ease of terminating the plastic fiber cable. The key parameters of links configured with the HFBR-0500 family are fully guaranteed. The HFBR-0500 evaluation kit contains all the components and literature necessary to evaluate a working link.

Mechanical Dimensions



Ordering Guide

Connectored Plastic Fiber Optic Cable

Single Channel	Dual Channel	Length* (metres)
HFBR-3500**	HFBR-3600**	Customer Specified
HFBR-3501	——	0.1
HFBR-3502	HFBR-3602	0.5
HFBR-3503	HFBR-3603	1
HFBR-3504	HFBR-3604	5
HFBR-3505	HFBR-3605	10
HFBR-3506	HFBR-3606	15
HFBR-3507	HFBR-3607	20
HFBR-3508	HFBR-3608	25

*All cable lengths are +10%, -0% tolerance.

**HFBR-3500, HFBR-3600 Ordering Information

These cable assemblies of customer specified length, have factory installed connectors. The length must be specified in 1 metre increments. The mandatory OPT 001, specifies the number of assemblies of equal length ordered.

EXAMPLE: To order 3 Duplex cable assemblies, 21 metres each, specify

HFBR-3600	Quantity 63
OPT 001	Quantity 3

Modules/Connectors

HFBR-1501/1502 Transmitters
HFBR-2501/2502 Receivers
HFBR-4501 Gray Connector/Crimp Ring
HFBR-4511 Blue Connector/Crimp Ring

Unconnectored Plastic Fiber Optic Cable

Single Channel	Dual Channel	Length* (metres)
HFBR-3589	HFBR-3689	25
HFBR-3590	HFBR-3690	100
HFBR-3591	HFBR-3691	500

HFBR-4595 Polishing Kit

Polishing Fixture — Abrasive Paper

HFBR-0500 Evaluation Kit

HFBR-1501	Transmitter (Gray)
HFBR-2501	Receiver (Blue)
HFBR-3504	5m Connectored Cable
HFBR-4501	Connector/Crimp Ring (Gray)
HFBR-4511	Connector/Crimp Ring (Blue)
HFBR-4595	Polishing Kit
Technical Literature	

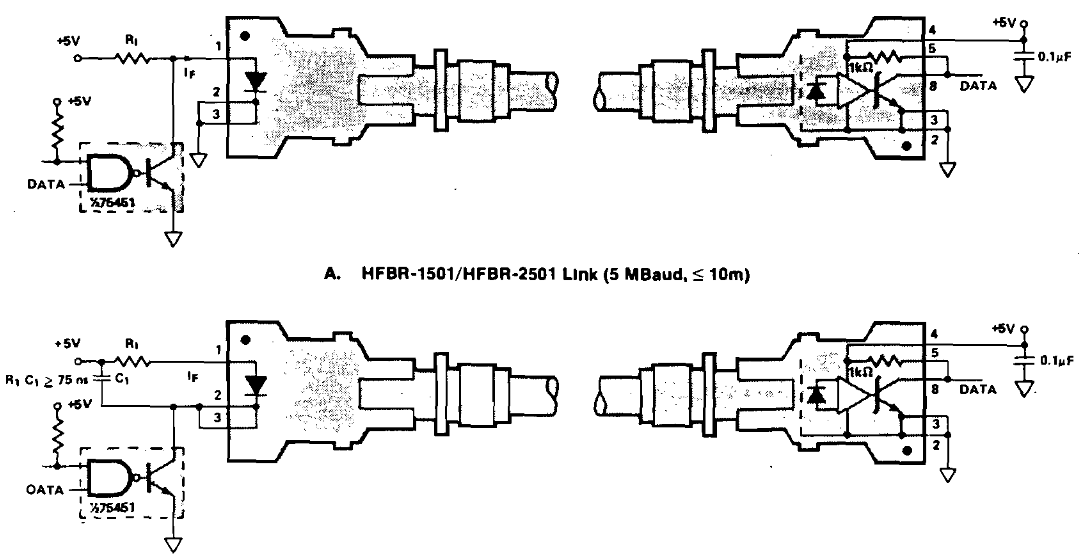
Link Design Considerations

The first step in designing the link is to choose either the HFBR-1501/2501 or the HFBR-1502/2502 Transmitter/Receiver pair based on the data-rate and distance requirements. The value of the transmitter drive current, I_F, must be determined next from Figure 2. For the HFBR-1501/2501 pair (Figure 2A), note that there is an upper as well as a lower limit on the value of I_F for any given distance. The dotted lines in Figure 2A and Figure 2B represent pulsed operation. When operating in the pulsed mode, the conditions in Note 1 must be met.

After selecting a value for the transmitter drive current I_F, the value of R_1 in Figure 1 can be calculated as follows:

$$R_1 = \frac{V_{CC} - V_F}{I_F}$$

For the HFBR-1502/2502 pair, the value of the capacitor, C_1 (Figure 1B), must be chosen such that $R_1 C_1 \geq 75$ ns.



A. HFBR-1501/HFBR-2501 Link (5 MBaud, ≤ 10m)

B. HFBR-1502/HFBR-2502 Link (1 MBaud, ≤ 22m)

Figure 1. Typical Circuit Configuration

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Ref.
AMBIENT TEMPERATURE	T_A	0	70	°C	
TRANSMITTER Peak Forward Current	$I_{F\,PK}$	10	750	mA	Note 1
Avg. Forward Current	$I_{F\,AV}$		60	mA	
RECEIVER Supply Voltage	V_{CC}	4.75	5.25	V	Note 2
Fan-Out (TTL)	N		5		
CABLE Long Term Bend Radius	r	35		mm	Note 3
Long Term Tensile Load	F_T		1	N	

System Performance

Parameter	Symbol	Min.	Typ. (17)	Max.	Units	Conditions	Ref.
HFBR-1501/HFBR-2501							
Data Rate		dc		5	MBd	$BER \leq 10^{-9}$	
Transmission Distance	ℓ	10			m	I_{FPK} = 60 mA, 0-70°C	
		17			m	I_{FPK} = 60 mA, 25°C	
Propagation Delay	t_{PLH}			140	ns	$R_L = 560\Omega$, $C_L = 30$ pF	Fig. 5, 3
	t_{PHL}			140	ns	$-21.6 \leq P_R \leq -9.5$ dBm	Note 4
Pulse Width Distortion	t_{SK}		30		ns	P_R = -15 dBm	Fig. 4 Note 5
HFBR-1502/HFBR-2502							
Data Rate		dc		1	MBd	$BER \leq 10^{-9}$	
Transmission Distance	ℓ	16			m	I_{FPK} = 60 mA, 0-70°C	
		23			m	I_{FPK} = 60 mA, 25°C	
Transmission Distance (50% Duty Factor Max.)	ℓ	22			m	I_{FPK} = 120 mA, 0-70°C	
		29			m	I_{FPK} = 120 mA, 25°C	
Propagation Delay	t_{PLH}			250	ns	$R_L = 560\Omega$, $C_L = 30$ pF	Fig. 5, 3
	t_{PHL}			140	ns	P_R = -24 dBm	Note 4
Pulse Width Distortion	t_{SK}		80		ns	P_R = -24 dBm	Fig. 4 Note 5
HFBR-150X/250X							
EMI Immunity			8000		V/m	$BER \leq 10^{-9}$	

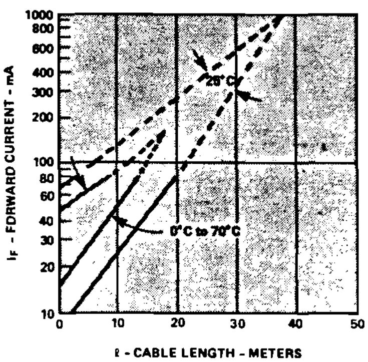


Figure 2A. System Performance with HFBR-1501 and HFBR-2501

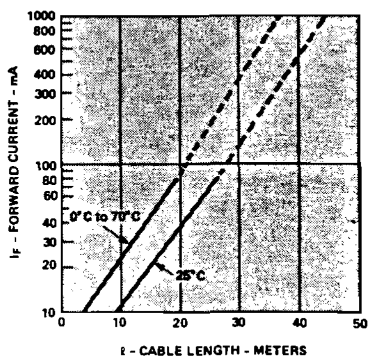
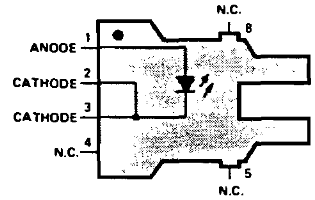


Figure 2B. System Performance with HFBR-1502 and HFBR-2502

Transmitters

The gray plastic HFBR-1501/1502 Transmitter modules incorporate a 665nm LED targeted at the low attenuation window for the HFBR-3500/3600 plastic fiber optic cable. The transmitters can be easily interfaced to standard TTL logic. The optical power output of the HFBR-1501/1502 is specified at the end of 0.5m of cable.

HFBR-1501/1502 Transmitter



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp			260	°C	Note 6
	Time			10	sec	
Peak Forward Input Current		$I_{F\,PK}$		1000	mA	Note 7
Average Forward Input Current		$I_{F\,AV}$		80	mA	
Reverse Input Voltage		V_R		5	V	

Electrical/Optical Characteristics (Cont.) 0°C to +70°C Unless Otherwise Specified

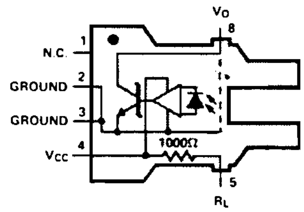
Parameter		Symbol	Min.	Typ.(17)	Max.	Units	Conditions	Ref.
Transmitter Output Optical Power	HFBR-1501	P_T	-14.8		-8.4	dBm	I_F = 60mA, 0-70°C	Note 8
			-11.7		-9.3	dBm	I_F = 60mA, 25°C	Note 9
	HFBR-1502	P_T	-13.6		-5.5	dBm	I_F = 60mA, 0-70°C	
			-10.4		-6.4	dBm	I_F = 60mA, 25°C	
Output Optical Power Temperature Coefficient		$\frac{\Delta P_T}{\Delta T}$		-0.026		dB/°C		
Peak Emission Wavelength		λ_{PK}		665		nm		
Forward Voltage		V_F	1.45	1.67	2.02	V	I_F = 60 mA	
Forward Voltage Temperature Coefficient		$\frac{\Delta V_F}{\Delta T}$		-1.37		mV/°C		
Effective Diameter		D_T		1		mm		
Numerical Aperture		N.A.		0.5				
Reverse Input Breakdown Voltage		V_{BR}	5.0	12.4		V	I_F = -10 μA, T_A = 25°C	
Diode Capacitance		C_O		86		pF	V_F = 0, f = 1 MHz	

WARNING: When viewed under some conditions, the optical port of the Transmitter may expose the eye beyond the Maximum Permissible Exposure recommended in ANSI Z-136-1, 1981. Under most viewing conditions there is no eye hazard.

Receivers

The blue plastic HFBR-2501/2502 Receiver modules feature a shielded integrated photodetector and wide bandwidth DC amplifier for high EMI immunity. A Schottky clamped open-collector output transistor allows interfacing to common logic families and enables "wired-OR" circuit designs. The open collector output is specified up to 18V. An integrated 1000 ohm resistor internally connected to V_{CC} may be externally jumpered to provide a pull-up for ease-of-use with +5V logic. The combination of high optical power levels and fast transitions falling edge could result in distortion of the output signal (HFBR-2502 only), that could lead to multiple triggering of following circuitry. Optical power waveshaping circuitry as in Figure 1B may be required for proper link operation.

HFBR-2501/2502 Receiver



Absolute Maximum Ratings

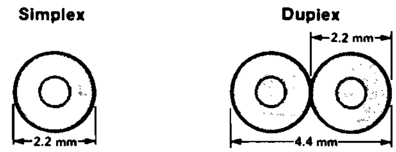
Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp			260	°C	Note 6
	Time			10	sec	
Supply Voltage		V_{CC}	-0.5	7	V	
Output Collector Current		I_O		25	mA	
Output Collector Power Dissipation		P_{OD}		40	mW	
Output Voltage		V_O	-0.5	18	V	
Pullup Voltage		V_{RL}	-0.5	V_{CC}	V	

Electrical/Optical Characteristics (Cont.) 0°C to +70°C Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.(17)	Max.	Units	Conditions	Ref.
Receiver Input Optical Power Level for Logic "0"	HFBR-2501	$P_{R(L)}$	-21.6		-9.5	dBm	0-70°C, V_{OL} = 0.5V I_{OL} = 8 mA	Note 9, 10
			-21.6		-8.7	dBm	25°C, V_{OL} = 0.5V I_{OL} = 8 mA	
	HFBR-2502	$P_{R(L)}$	-24			dBm	0-70°C, V_{OL} = 0.5V I_{OL} = 8 mA	
			-24			dBm	25°C, V_{OL} = 0.5V I_{OL} = 8 mA	
Input Optical Power Level for Logic "1"		$P_{R(H)}$			-43	dBm	V_{OH} = 5.25V, $I_{OH} \leq 250\ \mu A$	Note 9
High Level Output Current		I_{OH}		5	250	μA	V_O = 18V, P_R = 0	Note 16
Low Level Output Voltage		V_{OL}		0.4	0.5	V	I_{OL} = 8 mA, $P_R = P_{RL\ MIN}$	Note 16
High Level Supply Current		I_{CCH}		3.5	6.3	mA	V_{CC} = 5.25V, ϕ_R = 0	Note 16
Low Level Supply Current		I_{CCL}		6.2	10	mA	V_{CC} = 5.25V, P_R = -12.5 dBm	Note 16
Effective Diameter		D_R		1		mm		
Numerical Aperture		$N.A._R$		0.5				
Internal Pull-Up Resistor		R_L		1000		Ohms		

Plastic Fiber Cable

The HFBR-3500/3600 series cables contain 1mm diameter plastic fibers. These cables are extremely easy to connector. Simplex (HFBR-3500) and Duplex (HFBR-3600) cables are available with or without factory installed connectors.



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Installation Temperature		T_I	-20	+70	°C	
Tensile Force	(Single Channel)	F_T		50	N	Note 11
	(Dual Channel)	F_T		100	N	
	Cable/Connector	F_T		5	N	
Bend Radius		r	10		mm	Note 12
Flexing				1000	Cycles	Note 13
Impact		m		1	kg	Note 14
		h		15	mm	

Electrical/Optical Characteristics 0° C to +70° C Unless Otherwise Specified

Parameter	Symbol	Min.	Typ. (17)	Max.	Units	Conditions	Ref.
Link Coupling Variation	$\Delta\alpha_{LC}$		0.9	2.0	dB		Note 15
Cable Attenuation	α_0	0.3	0.45	0.63	dB/m	@665 nm Source NA = 0.5	
Numerical Aperture	N.A.		0.5			$\ell > 2$ m	
Diameter, Core	D_C		1.0		mm		
Diameter, Jacket	D_J		2.2		mm	Simplex Cable	
Delay	t_{pdc}		5.0		nsec/m		
Mass per Unit Length/Channel	m/ℓ		4.6		g/m	Without Connectors	
Cable Leakage Current	I_L		1		nA	10 kV, $\ell = 0.1$m	

CABLE TERMINATIONS

Connectoring the cable is accomplished with the Hewlett-Packard HFBR-4595 Polishing Kit consisting of a Polishing Fixture and 600 grit abrasive paper. No adhesive material is needed to secure the cable in the connector, and the connector can be used immediately after polishing.

Connectors may be easily installed on the cable ends with readily available tools. Materials needed for the terminating procedure are:

1) HFBR-3500/3600 Fiber Optic Cable
2) HFBR-4595 Polishing Fixture, 600 grit sand paper
3) HFBR-4501 Connector crimp ring (gray)
4) HFBR-4511 Connector crimp ring (blue)
5) Industrial Razor Blade
6) 16 gauge latching wire strippers
7) Crimp Tool, AMP 90364-2

The zip cord structure of the HFBR-3600 duplex cable permits easy separation of the channels. The channels should be separated approximately 50 mm back from the ends to permit connectoring and polishing.

After cutting the cable to the desired length, strip off approximately 7 mm (0.275 in) of the outer jacket with the 16 guage wire strippers.

Place the crimp ring and connector over the end of the cable; the fiber should protrude about 3 mm (0.120 in) through the end of the connector. Carefully position the ring so that it is entirely on the connector and then crimp the ring in place with the crimping tool.

NOTE: Place the gray connector on the cable end to be connected to the transmitter and the blue connector on the cable end to be connected to the receiver to maintain the color coding (both connectors are the same mechanically).

Any excess fiber protruding from the connector end may be trimmed with the razor blade; however, the trimmed fiber should extend at least 1.5 mm (0.060 in) from the connector end.

Insert the connector fully into the polishing fixture with the connector end protruding from the bottom of the fixture.

NOTE: The four dots on the bottom of the polishing fixture are wear indicators. Replace the polishing fixture when any dot is no longer visible.

Using a figure-eight motion of the polishing fixture on the 600 grit abrasive, trim the fiber and the connector until the connector is flush with the end of the polishing fixture. The fiber end should be flat and smooth with no large irregularities.

The cable can now be used.

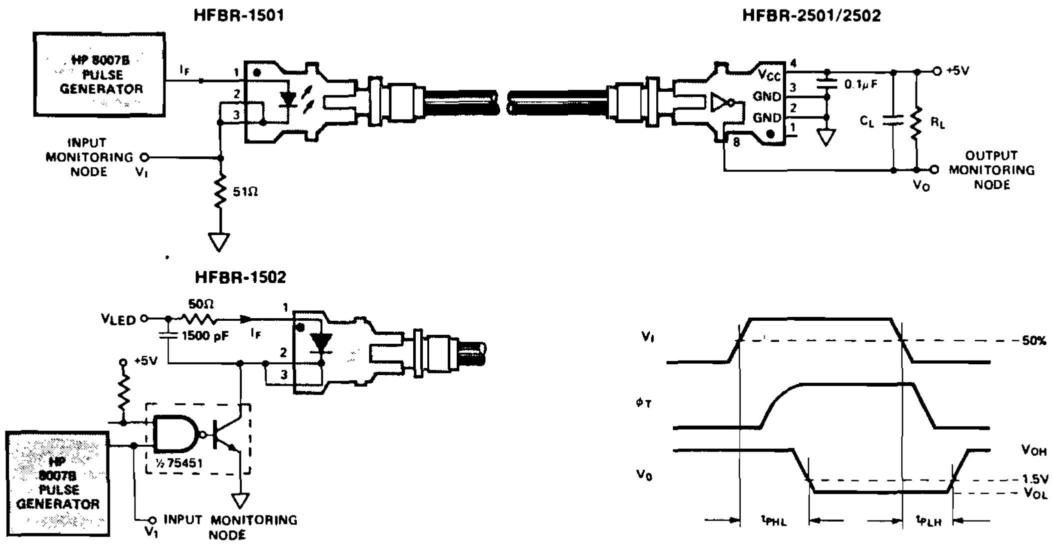


Figure 3. AC Test Circuit

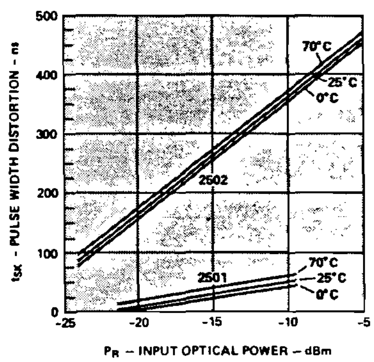


Figure 4. Pulse Width Distortion vs. Optical Power

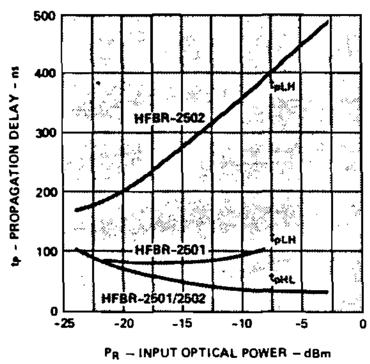


Figure 5. Propagation Delay vs. Optical Power

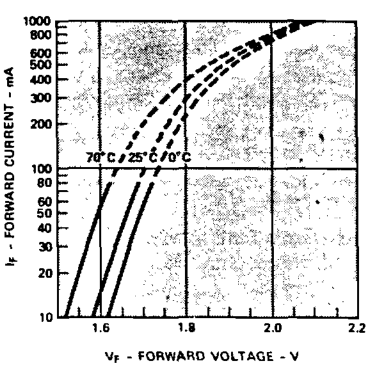


Figure 6. Forward Current vs. Forward Voltage

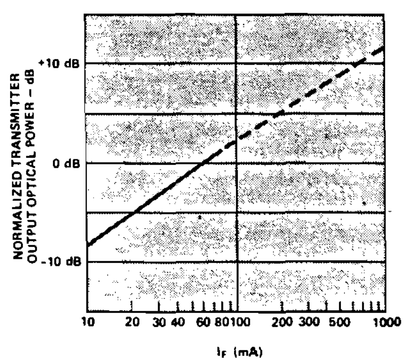


Figure 7. Normalized Transmitter Output Optical Power vs. Input Current

Optic Power Measurement

The optical power at the end of the HFBR-3500 series Fiber Optic Cable can be easily measured using a large area Radiometer such as the EG&G-550, Photodyne 88XL, or United Detector Technology S550, that has been calibrated at 665 nm.

The output optical power for the Transmitter has been specified at the end of 0.5 metres of HFBR-3500 Fiber Optic Cable and can therefore be easily measured using one of the above instruments.

Extended Distance Operation

Distances greater than 22m (0 - 70° C), are achievable by using high peak current pulses to drive the Transmitter. I_{FAV} must be limited to 80 mA and I_{FPK} to 1000 mA. The pulse width must be controlled. (Note 1).

Figure 8 shows a simple circuit suitable for RS-232 applications using the HFBR-1502 Transmitter and HFBR-2502 Receiver for 30 metre operation.

I_{FPK} = 500 mA (From Figure 2B, ℓ = 31 m); I_{FAV} = 25 mA at a Data Rate of 55 Kbd or less, Pulse Width Distortion < 25% (4.5 μs max.)

NOTE: I_{FPK} up to 1000 mA may be used for distances up to 35m.

An MOS clock driver may be used to provide transient current sinking capability up to 1000 mA.

Even longer distances can be achieved using specially selected components — contact your local Hewlett-Packard Sales Representative.

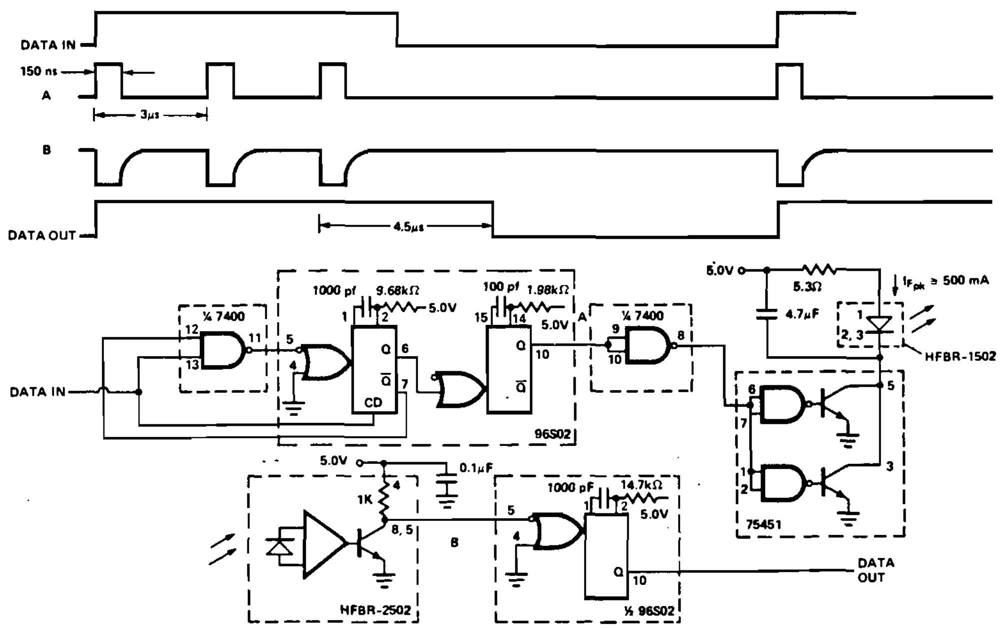


Figure 8. Pulsed Operation

NOTES:

1. For I_{FPK} > 80 mA, the duty factor must be such as to keep $I_{FAV} \leq$ 80 mA. In addition, for I_{FPK} > 80 mA, the following rules for pulse width apply:
   $I_{FPK} \leq$ 160 mA : Pulse width $\leq$ 1 ms
   I_{FPK} > 160 mA : Pulse width $\leq$ 1 μs
2. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 3 to pin 4 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.
3. See cable absolute maximum ratings for short-term bend radius and tensile load.
4. The propagation delay of 1m of cable (4.5 ns) is included.
5. $t_{SK} = t_{PLH} - t_{PHL}$; R_L = 560Ω, C_L = 30 pF.
6. 1.6 mm below seating plane.
7. 1 μs pulse, 20 μs period.
8. Measured at the end of 0.5m HFBR-3502 Fiber Optic Cable with a large area detector.
9. Optical flux, P (dBm) = 10 Log P (μW)/1000 μW.
10. Measured at the end of HFBR-3500 Fiber Optic Cable with large area detector.
11. Less than 30 minutes.
12. Less than 1 hour, non-operating.
13. 90° bend on 10 mm radius mandrel.
14. 1 Kg weight dropped from 15 mm height on 2.5 mm radius mandrel laid on cable.
15. Included in P_T and P_R.
16. R_L is open.
17. Typical data at 25° C, V_{CC} = 5 V_{dc}.

INTERSIL

IVN6000 CN Series
IVN6000 TN Series
500V n-Channel
Enhancement-mode
Vertical Power MOSFETs

FEATURES

- High speed, high current switching
- Inherent current sharing capability when paralleled
- Directly interfaces to CMOS logic
- Extended safe operating area
- Inherently temperature stable

ABSOLUTE MAXIMUM RATINGS

(T_A = 25° C unless otherwise noted)

Drain-source Voltage	
IVN6000 CNR, TNR	395V
IVN6000 CNS, TNS	400V
IVN6000 CNT, TNT	450V
IVN6000 CNU, TNU	500V
Drain-gate Voltage	
IVN6000 CNS, TNS	400V
IVN6000 CNT, TNT	450V
IVN6000 CNU, TNU	500V
Continuous Drain Current (Note 1)	
IVN6000 CNS, CNT	2A
IVN6000 CNU, CNR	1.75A
IVN6000 TNS, TNT	1.0A
IVN6000 TNU	0.9A
Peak Drain Current (see note 2)	
CN devices	6A
TN devices	5A
Gate-source Voltage	± 30V
Thermal Resistance, Junction to Case	
CN devices	3.13°C/W
TN devices	10°C/W
Continuous Device Dissipation at (or below) 25°C Case Temperature, CN devices	30W
TN devices	12.5W
Linear Derating Factor	
CN devices	320mW/°C
TN devices	100mW/°C
Operating Junction Temperature Range	− 55°C to + 150°C
Storage Temperature Range	− 55°C to + 150°C
Lead Temperature (1/16" in. from case for 10 sec)	+ 300°C
Reverse Diode Continuous Forward Current	
CN devices	2A
TN devices	1A
Reverse Diode Peak Forward Current	
CN devices	6A
TN devices	5A

Note 1. T_C = 25°C; limited by $r_{DS(on)}$ and maximum power dissipation.

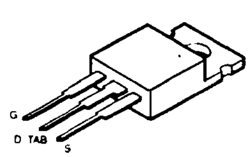
Note 2. Maximum pulse width 80μ sec maximum duty cycle 1.0%.

Note 3. The Drain-source diode is an integral part of the MOSFET structure.

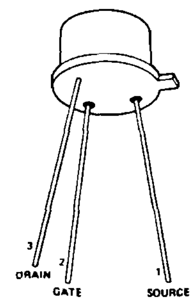
APPLICATIONS

- Switching power supplies
- DC to DC inverters
- Motor controllers
- Power amplifiers
- RF amplifiers

PIN CONFIGURATION

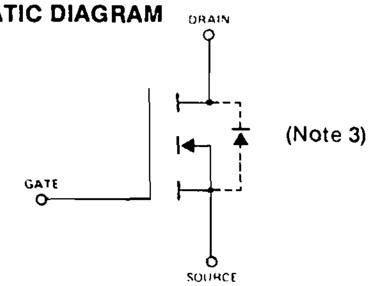


CN Series TO-220



TN Series TO-39

SCHEMATIC DIAGRAM



Body internally connected to source.
Drain common to case.

ORDERING INFORMATION

IVN6000 C N S

- S — Breakdown voltage: S = 400V, T = 450V, U = 500V
- N — No Zener
- C — Package: C = TO-220, T = TO-39
- IVN6000 — Basic part number

See 6000 Geometry.

IVN6000 CN Series

INTERSIL

ELECTRICAL CHARACTERISTICS (25°C unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITIONS	LIMITS MIN.	LIMITS TYP.	LIMITS MAX.	UNIT
Drain-Source Breakdown Voltage	BV_{DSS}	$V_{GS} = 0V$, $I_D = 100\ \mu A$				
IVN6000 CNR, TNR			395			V
IVN6000 CNS, TNS			400			V
IVN6000 CNT, TNT			450			V
IVN6000 CNU, TNU			500			V
Gate-Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}$, $I_D = 10mA$	2		5	V
Gate-Body Leakage Current	I_{GSS}	$V_{GS} = 30V$		10	100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = Maximum Rating, $V_{GS} = 0V$, $T_J = 125°C$ (Note 2)		0.2	2	mA
ON Drain Current[1]	$I_{D(on)}$	$V_{DS} = 50V$, $V_{GS} = 15V$ — CN devices	4			A
		$V_{DS} = 50V$, $V_{GS} = 15V$ — TN devices	3			A
Static-Drain Source ON Resistance[1]						
IVN6000 CNR	$r_{DS(on)}$	$V_{GS} = 15V$, $I_D = 1A$			5.0	Ω
IVN6000 CNS, CNT	$r_{DS(on)}$	$V_{GS} = 15V$, $I_D = 1A$			3.5	Ω
IVN6000 CNU					4.0	Ω
Forward Transconductance[1]	g_{fs}	$V_{DS} = 200V$, $I_D = 1.5A$	0.8	1.1		mho
Input Capacitance	C_{iss}	$V_{DS} = 100V$, f = 1.0 MHz, (Note 2) $V_{GS} = 0V$		220	275	pF
Output Capacitance	C_{oss}	$V_{DS} = 100V$, f = 1.0 MHz, (Note 2) $V_{GS} = 0V$		22	30	pF
Reverse Transfer Capacitance	C_{rss}	$V_{DS} = 100V$, f = 1.0 MHz, (Note 2) $V_{GS} = 0V$		6	10	pF
Rise Time	t_r	$V_{DS} = 200V$, $I_D = 1.0A$, $V_{GS} = 15V$, $R_{gen} = 6\Omega$ — See Switching Times Test Circuit			10	ns
Fall Time	t_f	$V_{DS} = 200V$, $I_D = 1.0A$, $V_{GS} = 15V$, $R_{gen} = 6\Omega$ — See Switching Times Test Circuit			10	ns
Slew Rate	SR	$V_{GS} = 0V$, V_{DS} = 80% of rating		100		V/ns

Note 1: Pulse test 80μs, 1% duty cycle.
Note 2: Sample test only.

REVERSE DIODE CHARACTERISTICS

PARAMETER	SYMBOL	TEST CONDITIONS	LIMITS MIN.	LIMITS TYP.	LIMITS MAX.	UNIT
Forward Voltage Drop	V_f	Forward Current = 2A		0.85	1.1	V
Reverse Recovery Time	t_{rr}	$I_{fwd(pk)} = I_{rev(pk)}$ Recovery to 50%		200		ns
Recovered Charge	Q_{rr}	$T_J = 150°C$, $I_{fwd(pk)} = 2A$		400		nC

Note 3: See 6000 family characteristic curves.

National Semiconductor

MOS Clock Drivers

DS0026, DS0056 5 MHz Two-Phase MOS Clock Drivers

General Description

DS0026/DS0056 are low cost monolithic high speed two phase MOS clock drivers and interface circuits. Unique circuit design provides both very high speed operation and the ability to drive large capacitive loads. The device accepts standard TTL/DTL outputs and converts them to MOS logic levels. They may be driven from standard 54/74 series and 54S/74S series gates and flip-flops or from drivers such as the DS8830 or DM7440. The DS0026 and DS0056 are intended for applications in which the output pulse width is logically controlled; i.e., the output pulse width is equal to the input pulse width.

The DS0026/DS0056 are designed to fulfill a wide variety of MOS interface requirements. As a MOS clock driver for long silicon-gate shift registers, a single device can drive over 10k bits at 5 MHz. Six devices provide input address and precharge drive for a 8k by 16-bit 1103 RAM memory system. Information on the correct usage of the DS0026 in these as well as other systems is included in the application note AN-76A.

The DS0026 and DS0056 are identical except each driver in the DS0056 is provided with a V_{BB} connection to supply a higher voltage to the output stage. This aids in pulling up the output when it is in the high state. An external resistor tied between these extra pins and a supply higher than V^+ will cause the output to pull up to $(V^+ - 0.1V)$ in the off state.

For DS0056 applications, it is required that an external resistor be used to prevent damage to the device when the driver switches low. A typical V_{BB} connection is shown on the next page.

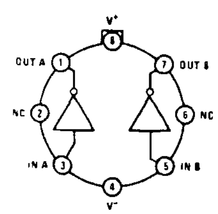
These devices are available in 8-lead TO-5, one watt copper lead frame 8-pin mini-DIP, and one and a half watt ceramic DIP, and TO-8 packages.

Features

- Fast rise and fall times—20 ns with 1000 pF load
- High output swing—20V
- High output current drive—±1.5 amps
- TTL/DTL compatible inputs
- High rep rate—5 to 10 MHz depending on power dissipation
- Low power consumption in MOS "0" state—2 mW
- Drives to 0.4V of GND for RAM address drive

Connection Diagrams (Top Views)

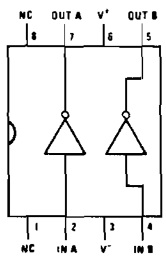
TO-5 Package



Note: Pin 4 connected to case.

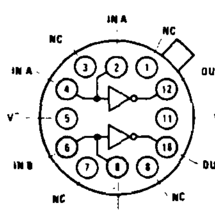
Order Number DS0026H
or DS0026CH
See NS Package H08C

Dual-In-Line Package



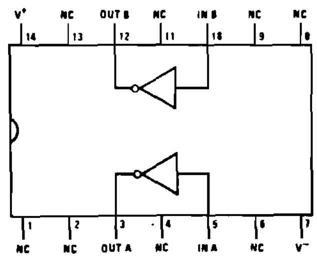
Order Number
DS0026CJ-8,
DS0026CN-8
or DS0026J-8
See NS Package J08A or N08A

TO-8 Package



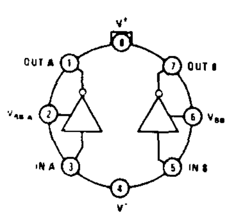
Order Number DS0026H
or DS0026CH
See NS Package H12B

Flat Package



Order Number DS0026W
See NS Package W14A

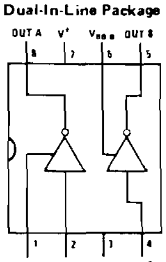
TO-5 Package



Note: Pin 4 connected to case

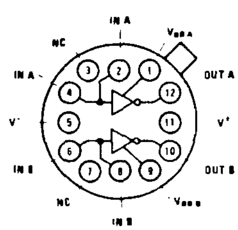
Order Number DS0056H
or DS0056CH
See NS Package H08C

Dual-In-Line Package



Order Number
DS0056J-8, DS0056CJ-8
or DS0056CN-8
See NS Package J08A or N08A

TO-8 Package



Order Number DS0056H
or DS0056CH
See NS Package H12B

Absolute Maximum Ratings (Note 1)

$V^+ - V^-$ Differential Voltage	22V
Input Current	100 mA
Input Voltage ($V_{IN} - V^-$)	5.5V
Peak Output Current	1.5A

Operating Temperature Range	
DS0026, DS0056	−55°C to +125°C
DS0026C, DS0056C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

Electrical Characteristics (Notes 2 and 3)

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
V_{IH}	Logic "1" Input Voltage	$V^- = 0V$		2	1.5		V
I_{IH}	Logic "1" Input Current	$V_{IN} - V^- = 2.4V$			10	15	mA
V_{IL}	Logic "0" Input Voltage	$V^- = 0V$			0.6	0.4	V
I_{IL}	Logic "0" Input Current	$V_{IN} - V^- = 0V$			−3	−10	μA
V_{OL}	Logic "1" Output Voltage	$V_{IN} - V^- = 2.4V$			V^-+0.7	V^-+1.0	V
V_{OH}	Logic "0" Output Voltage	$V_{IN} - V^- = 0.4V$, $V_{BB} \geq V^+ + 1.0V$	DS0026	V^+−1.0	V^+−0.7		V
			DS0056	V^+−0.3	V^+−0.1		V
$I_{CC(ON)}$	"ON" Supply Current	$V^+ - V^- = 20V$ $V_{IN} - V^- = 2.4V$	DS0026		30	40	mA
		(Note 6) (one side on)	DS0056		12	30	mA
$I_{CC(OFF)}$	"OFF" Supply Current	$V^+ - V^- = 20V$,	70°C		10	100	μA
		$V_{IN} - V^- = 0V$	125°C		10	500	μA

Switching Characteristics ($T_A = 25°C$) (Notes 5 and 7)

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
t_{ON}	Turn-on Delay	*(Figure 1)*		5	7.5	12	ns
		(Figure 2)			11		ns
t_{OFF}	Turn-off Delay	*(Figure 1)*			12	15	ns
		(Figure 2)			13		ns
t_r	Rise Time	*(Figure 1)*,	C_L = 500 pF		15	18	ns
		(Note 5)	C_L = 1000 pF		20	35	ns
		(Figure 2),	C_L = 500 pF		30	40	ns
		(Note 5)	C_L = 1000 pF		36	50	ns
t_f	Fall Time	*(Figure 1)*,	C_L = 500 pF		12	16	ns
		(Note 5)	C_L = 1000 pF		17	25	ns
		(Figure 2),	C_L = 500 pF		28	35	ns
		(Note 5)	C_L = 1000 pF		31	40	ns

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. Except for "Operating Temperature Range" they are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" provides conditions for actual device operation.

Note 2: These specifications apply for $V^+ - V^- = 10V$ to 20V, $C_L = 1000$ pF, over the temperature range of −55°C to +125°C for the DS0026, DS0056 and 0°C to +70°C for the DS0026C, DS0056C.

Note 3: All currents into device pins shown as positive, out of device pins as negative, all voltages referenced to ground unless otherwise noted. All values shown as max or min on absolute value basis.

Note 4: All typical values for the $T_A = 25°C$.

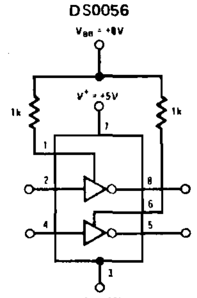
Note 5: Rise and fall time are given for MOS logic levels; i.e., rise time is transition from logic "0" to logic "1" which is voltage fall.

Note 6: I_{BB} for DS0056 is approximately $(V_{BB} - V^-)/1\ k\Omega$ (for one side) when output is low.

Note 7: The high current transient (as high as 1.5A) through the resistance of the external interconnecting V^- lead during the output transition from the high state to the low state can appear as negative feedback to the input. If the external interconnecting lead from the driving circuit to V^- is electrically long, or has significant dc resistance, it can subtract from the switching response.

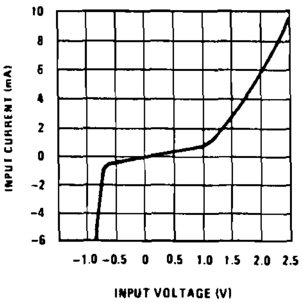
Typical V_{BB} Connection

DS0056

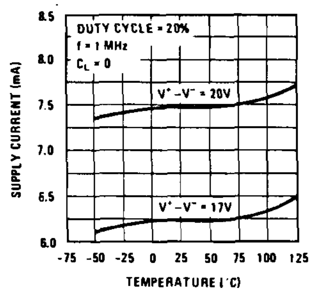


Typical Performance Characteristics

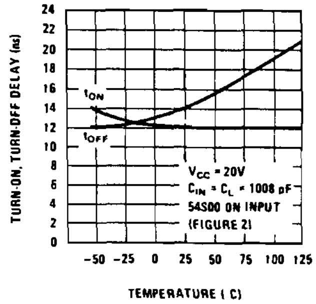
Input Current vs Input Voltage



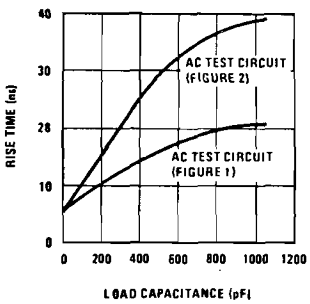
Supply Current vs Temperature



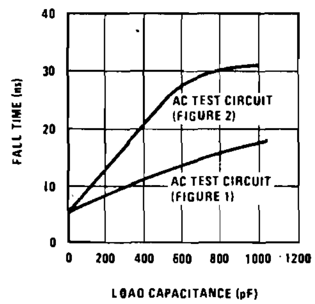
Turn-On and Turn-Off Delay vs Temperature



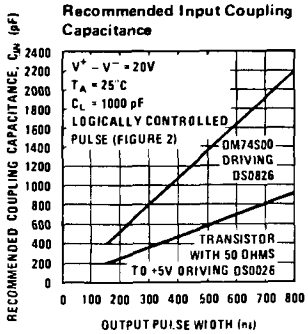
Rise Time vs Load Capacitance



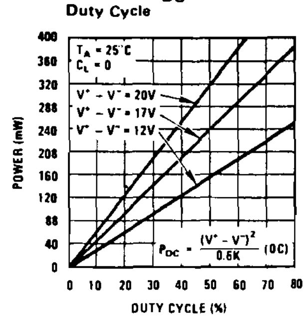
Fall Time vs Load Capacitance



Recommended Input Coupling Capacitance

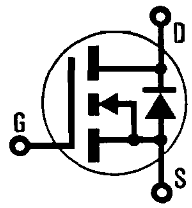


DC Power (P_{DC}) vs Duty Cycle



INTERNATIONAL RECTIFIER IOR

HEXFET® TRANSISTORS IRF520 IRF521 IRF522 IRF523



N-Channel

100 Volt, 0.3 Ohm HEXFET TO-220AB Plastic Package

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and great device ruggedness.

The HEXFET transistors also feature all of the well established advantages of MOSFETs such as voltage control, freedom from second breakdown, very fast switching, ease of paralleling, and temperature stability of the electrical parameters.

They are well suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers, and high energy pulse circuits.

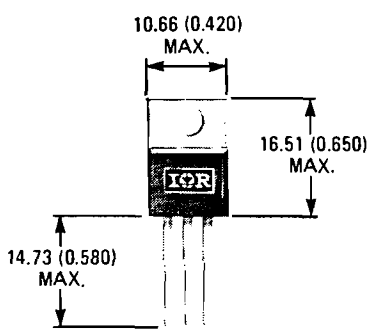
Features:

- Compact Plastic Package
- Fast Switching
- Low Drive Current
- Ease of Paralleling
- No Second Breakdown
- Excellent Temperature Stability

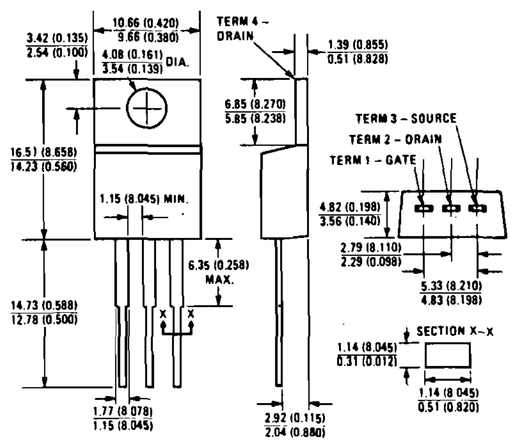
Product Summary

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF520	100V	0.30Ω	8.0A
IRF521	60V	0.30Ω	8.0A
IRF522	100V	0.40Ω	7.0A
IRF523	60V	0.40Ω	7.0A

CASE STYLE AND DIMENSIONS



ACTUAL SIZE



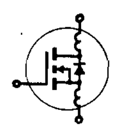
Case Style TO-220AB
Dimensions in Millimeters and (Inches)

IRF520, IRF521, IRF522, IRF523 Devices

Absolute Maximum Ratings

	Parameter	IRF520	IRF521	IRF522	IRF523	Units
V_{DS}	Drain - Source Voltage ①	100	60	100	60	V
V_{DGR}	Drain - Gate Voltage (R_{GS} = 1 MΩ) ①	100	60	100	60	V
I_D @ T_C = 25°C	Continuous Drain Current	8.0	8.0	7.0	7.0	A
I_D @ T_C = 100°C	Continuous Drain Current	5.0	5.0	4.0	4.0	A
I_{DM}	Pulsed Drain Current ③	32	32	28	28	A
V_{GS}	Gate - Source Voltage	± 20				V
P_D @ T_C = 25°C	Max. Power Dissipation	40 (See Fig. 14)				W
	Linear Derating Factor	0.32 (See Fig. 14)				W/K
I_{LM}	Inductive Current, Clamped	(See Fig. 15 and 16) L = 100μH 32	32	28	28	A
T_J T_{stg}	Operating Junction and Storage Temperature Range	-55 to 150				°C
	Lead Temperature	300 (0.063 in. (1.6mm) from case for 10s)				°C

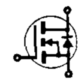
Electrical Characteristics @T_C = 25°C (Unless Otherwise Specified)

	Parameter	Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain - Source Breakdown Voltage	IRF520 IRF522	100	–	–	V	V_{GS} = 0V
		IRF521 IRF523	60	–	–	V	I_D = 250μA
$V_{GS(th)}$	Gate Threshold Voltage	ALL	2.0	–	4.0	V	V_{DS} = V_{GS}, I_D = 250μA
I_{GSS}	Gate-Source Leakage Forward	ALL	–	–	500	nA	V_{GS} = 20V
I_{GSS}	Gate-Source Leakage Reverse	ALL	–	–	-500	nA	V_{GS} = -20V
I_{DSS}	Zero Gate Voltage Drain Current	ALL	–	–	250	μA	V_{DS} = Max. Rating, V_{GS} = 0V
			–	–	1000	μA	V_{DS} = Max. Rating x 0.8, V_{GS} = 0V, T_C = 125°C
$I_{D(on)}$	On-State Drain Current ②	IRF520 IRF521	8.0	–	–	A	$V_{DS} > I_{D(on)} \times R_{DS(on)}$ max., V_{GS} = 10V
		IRF522 IRF523	7.0	–	–	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance ②	IRF520 IRF521	–	0.25	0.30	Ω	V_{GS} = 10V, I_D = 4.0A
		IRF522 IRF523	–	0.30	0.40	Ω	
g_{fs}	Forward Transconductance ②	ALL	1.5	2.9	–	S (℧)	$V_{DS} > I_{D(on)} \times R_{DS(on)}$ max., I_D = 4.0A
C_{iss}	Input Capacitance	ALL	–	450	600	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1.0 MHz See Fig. 10
C_{oss}	Output Capacitance	ALL	–	200	400	pF	
C_{rss}	Reverse Transfer Capacitance	ALL	–	50	100	pF	
$t_{d(on)}$	Turn-On Delay Time	ALL	–	20	40	ns	V_{DD} = 0.5 BV_{DSS}, I_D = 4.0A, Z_0 = 50Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.)
t_r	Rise Time	ALL	–	35	70	ns	
$t_{d(off)}$	Turn-Off Delay Time	ALL	–	50	100	ns	
t_f	Fall Time	ALL	–	35	70	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	ALL	–	10	15	nC	V_{GS} = 15V, I_D = 10A, V_{DS} = 0.8 Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	ALL	–	6.0	–	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	ALL	–	4.0	–	nC	
L_D	Internal Drain Inductance	ALL	–	3.5	–	nH	Measured from the contact screw on tab to center of die. / Modified MOSFET symbol showing the internal device inductances. 
			–	4.5	–	nH	Measured from the drain lead, 6mm (0.25 in.) from package to center of die.
L_S	Internal Source Inductance	ALL	–	7.5	–	nH	Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.

Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	–	–	3.12	K/W	
R_{thCS}	Case-to-Sink	ALL	–	1.0	–	K/W	Mounting surface flat, smooth, and greased.
R_{thJA}	Junction-to-Ambient	ALL	–	–	80	K/W	Free Air Operation

Source-Drain Diode Ratings and Characteristics

I_S	Continuous Source Current (Body Diode)	IRF520 IRF521	—	—	8.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier. 
		IRF522 IRF523	—	—	7.0	A	
I_{SM}	Pulse Source Current (Body Diode) ③	IRF520 IRF521	—	—	32	A	
		IRF522 IRF523	—	—	28	A	
V_{SD}	Diode Forward Voltage ②	IRF520 IRF521	—	—	2.5	V	$T_C = 25°C, I_S = 8.0A, V_{GS} = 0V$
		IRF522 IRF523	—	—	2.3	V	$T_C = 25°C, I_S = 7.0A, V_{GS} = 0V$
t_{rr}	Reverse Recovery Time	ALL	—	280	—	ns	$T_J = 150°C, I_F = 8.0A, dI_F/dt = 100A/\mu s$
Q_{RR}	Reverse Recovered Charge	ALL	—	1.6	—	μC	$T_J = 150°C, I_F = 8.0A, dI_F/dt = 100A/\mu s$
t_{on}	Forward Turn-on Time	ALL	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S + L_D$.				

① T_J = 25°C to 150°C. ② Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%. ③ Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Fig. 5).

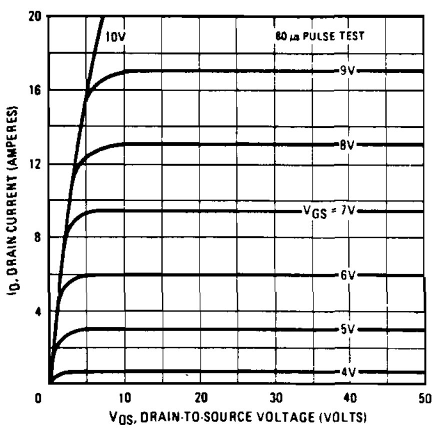


Fig. 1 — Typical Output Characteristics

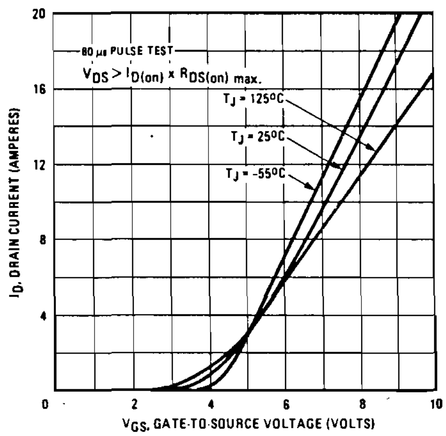


Fig. 2 — Typical Transfer Characteristics

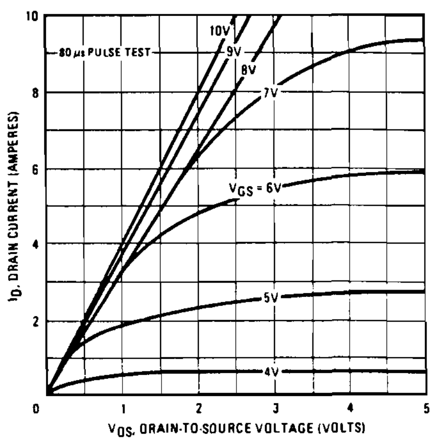


Fig. 3 — Typical Saturation Characteristics

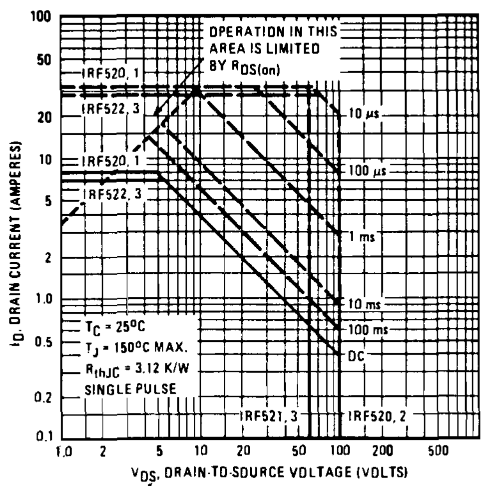


Fig. 4 — Maximum Safe Operating Area

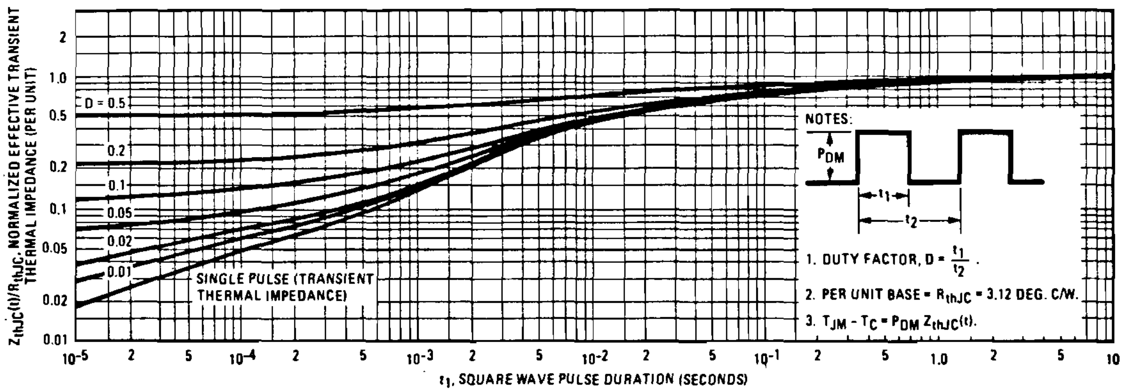


Fig. 5 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

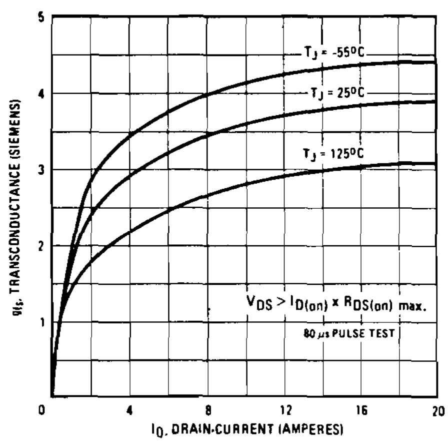


Fig. 6 — Typical Transconductance Vs. Drain Current

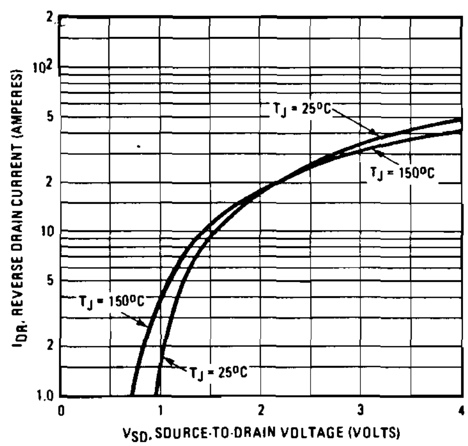


Fig. 7 — Typical Source-Drain Diode Forward Voltage

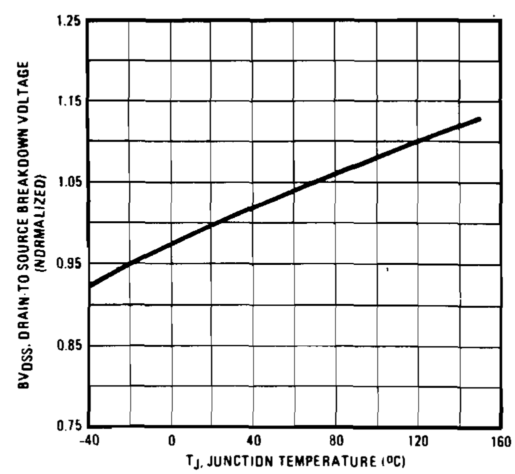


Fig. 8 — Breakdown Voltage Vs. Temperature

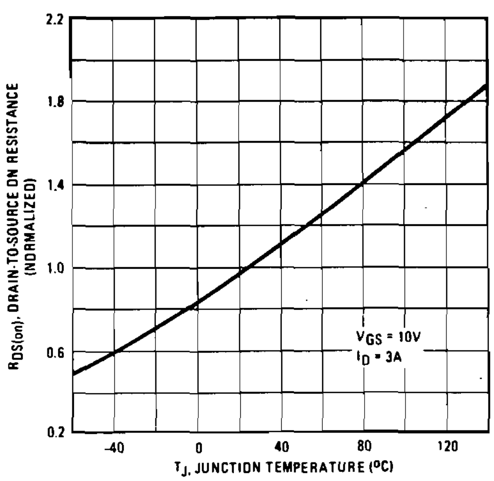


Fig. 9 — Normalized On-Resistance Vs. Temperature

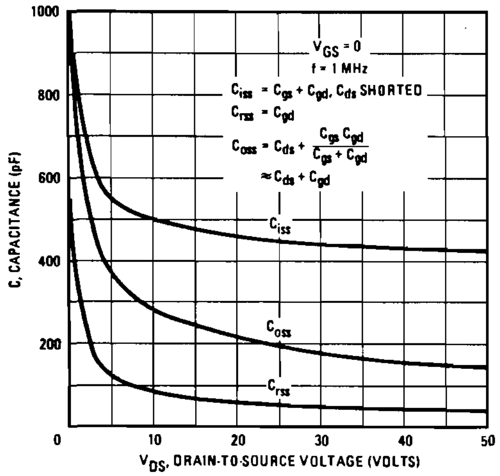


Fig. 10 – Typical Capacitance Vs. Drain-to-Source Voltage

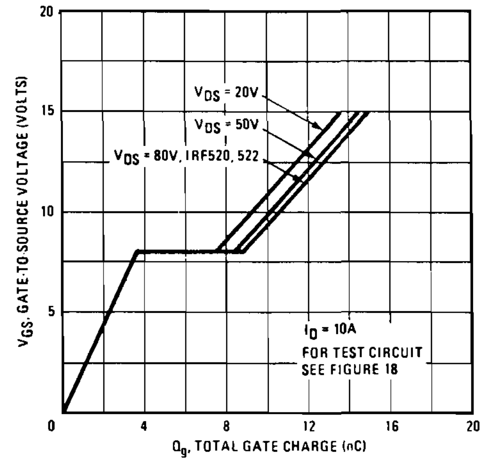


Fig. 11 – Typical Gate Charge Vs. Gate-to-Source Voltage

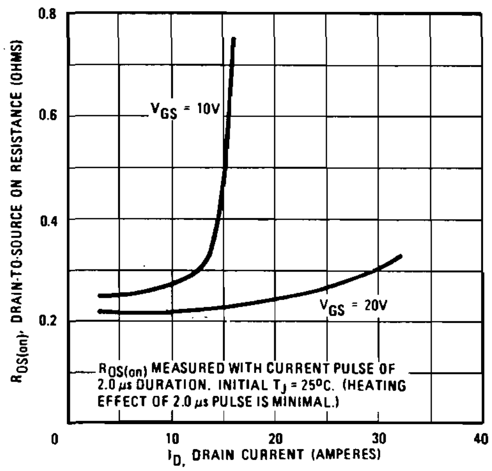


Fig. 12 – Typical On-Resistance Vs. Drain Current

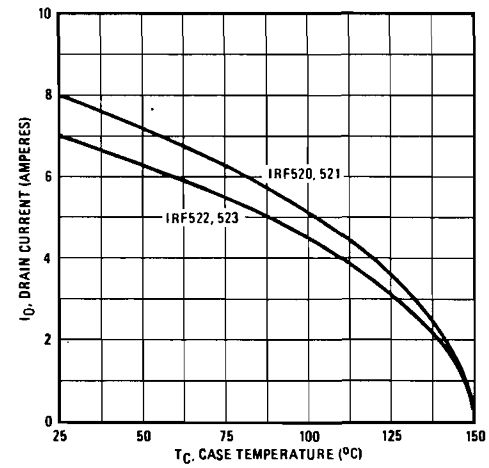


Fig. 13 – Maximum Drain Current Vs. Case Temperature

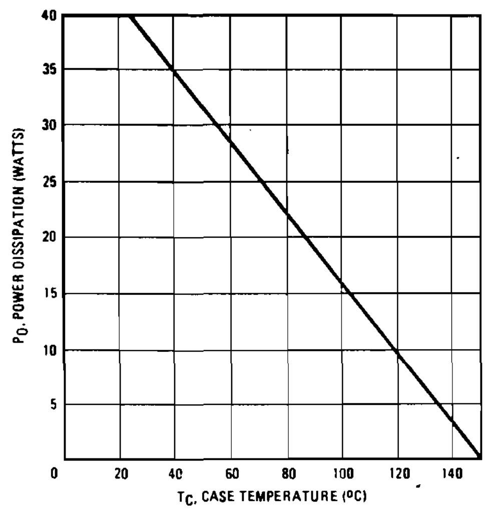


Fig. 14 – Power Vs. Temperature Derating Curve

Regulating Pulse Width Modulators

ADVANCED DATA

Performance data described herein represent design goals.
Final device specifications are subject to change.

SG1525A/2525A/3525A
SG1527A/2527A/3527A

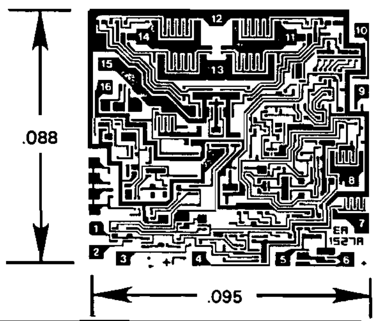
DESCRIPTION

The SG1525A/1527A series of pulse width modulator integrated circuits are designed to offer improved performance and lowered external parts count when used to implement all types of switching power supplies. The on-chip +5.1 volt reference is trimmed to ±1% initial accuracy and the input common-mode range of the error amplifier includes the reference voltage, eliminating external potentiometers and divider resistors. A Sync input to the oscillator allows multiple units to be slaved together, or a single unit to be synchronized to an external system clock. A single resistor between the C_T pin and the Discharge pin provides a wide range of deadtime adjustment. These devices also feature built-in soft-start circuitry with only a timing capacitor required externally. A Shutdown pin controls both the soft-start circuitry and the output stages, providing instantanious turn-off with soft-start recycle for slow turn-on. These functions are also controlled by an undervoltage lockout which keeps the outputs off and the soft-start capacitor discharged for input voltages less than that required for normal operation. Another unique feature of these PWM circuits is a latch following the comparator. Once a PWM pulse has been terminated for any reason, the outputs will remain off for the duration of the period. The latch is reset with each clock pulse. The output stages are totem-pole designs capable of sourcing or sinking 100 mA. The SG1525A output stage features NOR logic, giving a LOW output for an OFF state. The SG1527 utilizes OR logic which results in a HIGH output level when OFF.

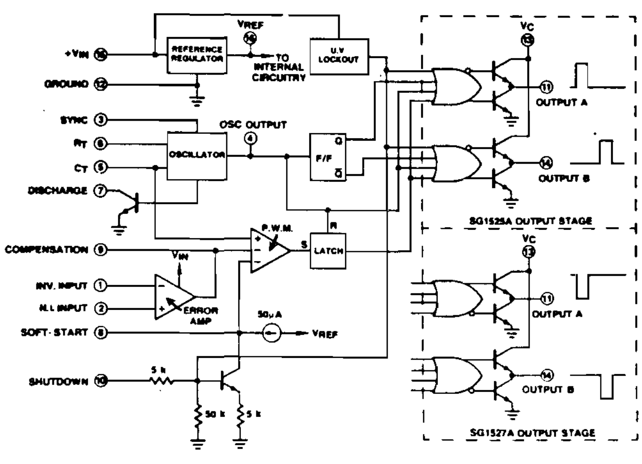
FEATURES

- **8 to 35 volt operation**
- **5.1 volt reference trimmed to ±1%**
- **100 Hz to 500 kHz oscillator range**
- **Separate oscillator sync terminal**
- **Adjustable deadtime control**
- **Internal soft-start**
- **Input undervoltage lockout**
- **Latching P.W.M. to prevent multiple pulses**
- **Dual 100 mA source/sink output drivers**

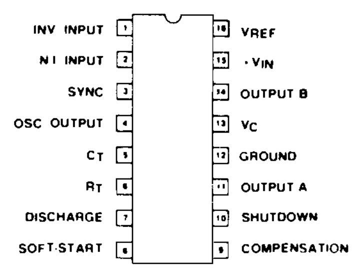
CHIP LAYOUT



BLOCK DIAGRAM

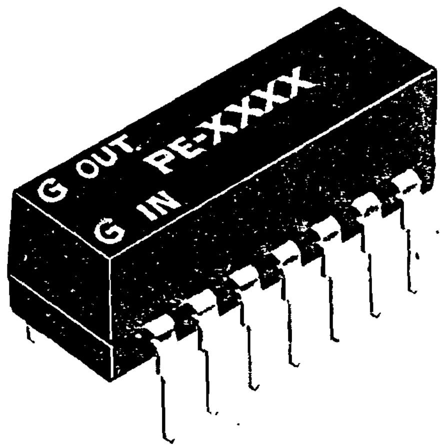


CONNECTION DIAGRAM
TOP VIEW



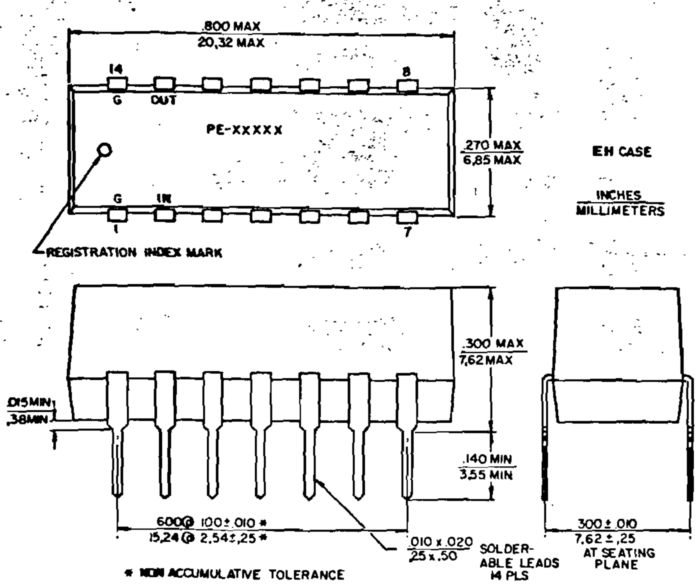
J-PACKAGE
TO-116

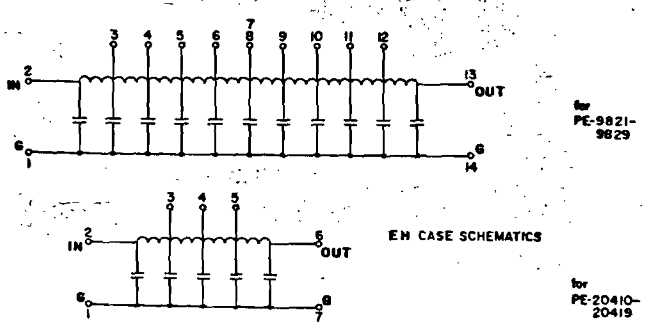
D-I-P DELAY LINES



- **FAST RISE TIME** — all delay lines feature fast rise time and low distortion.
- **DESIGNED FOR AUTOMATIC HANDLING**—this series of delay lines is fully compatible with automatic handling and insertion equipment.
- **PACKAGING** — all units are transfer molded and will meet applicable sections of MIL-D-23859 and MIL-STD-202C.
- **RATING RANGE** —

Temperature Coefficient	Approximately 100 PPM/°C
Peak Pulse Voltage	50 volts





ELECTRICAL SPECIFICATIONS*

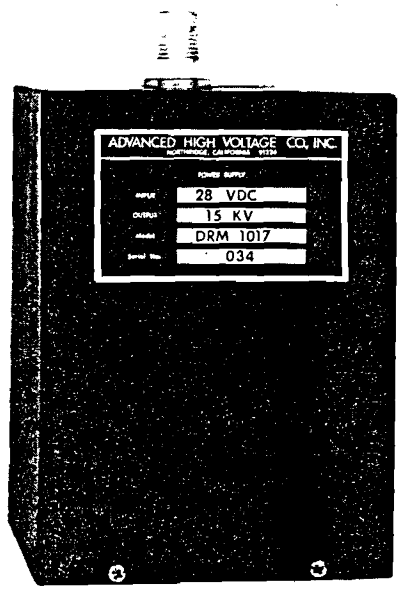
Catalog Number	Impedance Zo (ohms ±10%)	Total Delay (ns ±5%)	No. of Taps	Delay Per Tap (ns ±3 ns)	Rise Time (ns max.)	Total Delay/ Rise Time Ratio (min.)	Distortion (% max.)	Attenuation (% max.)
9821	50	50	10	5(±2 ns)	8.5	6	10	1.6
9822	50	100	10	10	17	6	10	3.8
9823	50	125	10	12.5	21	6	10	6.5
9824	100	50	10	5(±2 ns)	8.5	6	10	2.0
9825	100	100	10	10	17	6	10	4.0
9826	100	125	10	12.5	21	6	10	7.0
9827	100	150	10	15	25	6	10	8.0
9828	100	200	10	20	34	6	10	10.0
9829	100	250	10	25	42	6	10	12.0
20410	100	10	4	2.5(±1 ns)	4	3	15	5
20411	100	20	4	5.0(±2 ns)	7	3	15	5
20412	100	30	4	7.5(±2 ns)	10	3	15	5
20413	100	40	4	10	14	3	15	5
20414	100	50	4	12.5	17	3	15	5
20415	100	60	4	15	20	3	15	5
20416	100	70	4	17.5	24	3	15	5
20417	100	80	4	20	27	3	15	5
20418	100	90	4	22.5	30	3	15	5
20419	100	100	4	25	34	3	15	5

*Electrical Specifications Per E.I.A. Standard (RS - 242)

ADVANCED HIGH VOLTAGE CO., INC.

14532 ARMINTA AVE. • VAN NUYS. CALIF. 91402 • PHONE: (213) 997-7222

DRM SERIES
DC operated HV Module
800V to 22KV @ 15 watts. 28VDC input. Load and line regulated.



APPLICATIONS

CRT displays, image converters & similar photo-tube applications. General high voltage uses where close regulation, low ripple and small size are important.

FEATURES

Module type high voltage supply.
All solid state silicon.
Features line and load regulation.
Low ripple.
Short-circuit proof, output will recover upon removal of short.
Floating HV return. May be floated up to 500V from case or input.
Magnetically shielded.
Serviceable low voltage section.
Encapsulated high voltage section.

SPECIFICATIONS

Input: 28 VDC nominal.
Output: 800 V to 22 KV Adjustable ±10%.
Regulation — Line: < 0.1%. Load: < 0.1%.
Combined L/L: < 0.1%.

Ripple: < 0.1% rms
Operating temperature: −20°C to +65°C
Package: MIL-T-27 case.

Model Number	E nom KV	I max mA	Weight Lbs	Case Style
DRM 105	0.8	18	1½	GA
DRM 115	1	15	1½	GA
DRM 125	1.5	10	1½	GA
DRM 135	2.5	6	1¾	GA
→ DRM 145	3.5	4	1¾	GA
DRM 155	5	3	1¾	GA
DRM 165	7.5	2	1¾	GA
DRM 175	10	1.5	2	JA
DRM 185	12.5	1.2	2	JA
DRM 195	15	1	2	JA
DRM 205	18	0.8	2	JA
DRM 215	22	0.6	2	JA

MODIFICATIONS AND SPECIALS

Special DRM can be factory adjusted to any output voltage not listed, 200 V to 22 KV. Other specifications apply. Other input voltages. Very low ripple figures. Wider adjustment range.

Output externally programmable, voltage or resistance. Negative output polarity.

Units can be supplied with reverse input voltage protection or automatic selection of proper input polarity.

Units can be supplied foamed or epoxy-filled to withstand extreme environmental shock conditions.

OPERATING INSTRUCTIONS FOR DRM & DUM SERIES

1. The High Voltage output is on the top of the unit either a wire (high voltage lead) or a connector. The color of the lead has no bearing on the output polarity. The nameplate states the voltage and the polarity.

2. Other connections are on the bottom of the unit:
   - Pin 1 = Program input, 0 to 6.2 volts, the same polarity as the high voltage.
   - Pin 2 = Input return (negative DC).
   - Pin 3 = Positive DC input (+28 VDC)
   - Pin 4 = High voltage return.
   - Pin 5 = Program return.

3. To facilitate initial testing, unit is shipped with the output voltage adjusted to the nameplate voltage under a "no load" condition. Only the DC input (pin 3 & 2) need be connected to the unit for an operational check. Unit is designed for installation into systems and therefore does not contain reverse polarity protection.

4. The remote program capability is activated by connecting a low impedance drive voltage to the program input (pin 1). The program return lead goes to pin 5. Program voltage is approximately 6 volts for the nameplate output voltage, and of the same polarity. Program input impedance is approximately 100 Kohm. A low impedance program voltage automatically overrides the voltage set-in by trimpot RP 1.

5. Input return, high voltage return and program return are common and internally connected together. In the installation, they must be run separately in order to avoid ground loops. (During a high voltage short circuit, large amplitudes are present on the high voltage return and could damage the semiconductors used in the low-voltage section of the unit).

6. The case of the unit should normally be connected to the HV return, but may be floated within 500 volts of the input leads.

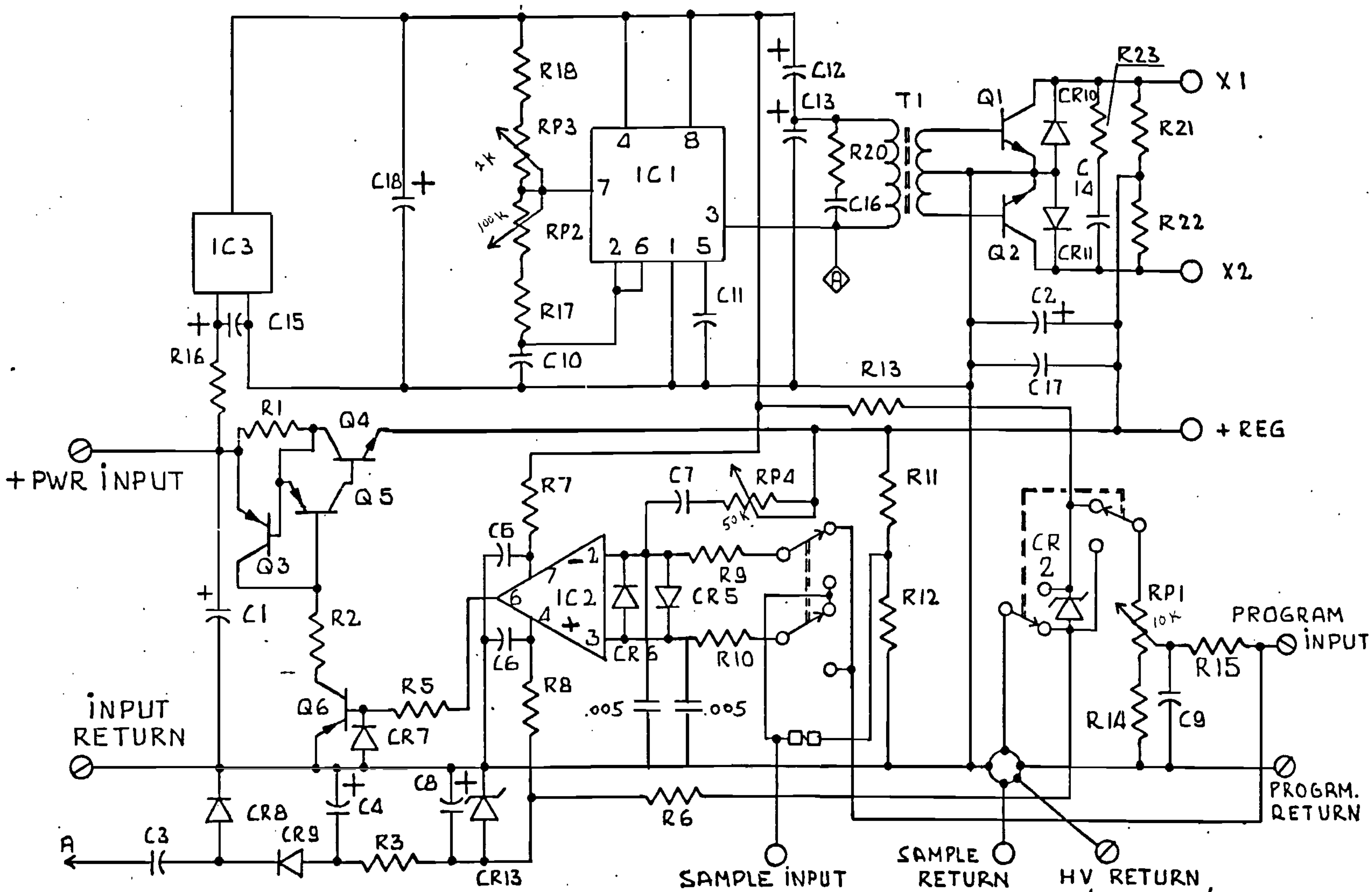
7. The bottom plate of the unit carries heat-generating components and should be installed on a flat metal surface. Heat-conducting paste should be used to insure good heat transfer. Heatsinking must limit the bottom plate temperature to 65°C, even during short circuits, where as much as 50 watts could be dissipated. (Only some units).

8. The 8-32 mounting screws must not penetrate more than one quarter of an inch (1/4") into the bottom plate.

9. The internal current limiting is set by R1. A lower-than-standard value of current limiting can be obtained by increasing R1. (Roughly .47 ohm for 1 Ampere input current). Smaller values of R1 can also be used on the units with -19 option. (This option supplies a 30 watt output on the DRM & DUM series of supplies).

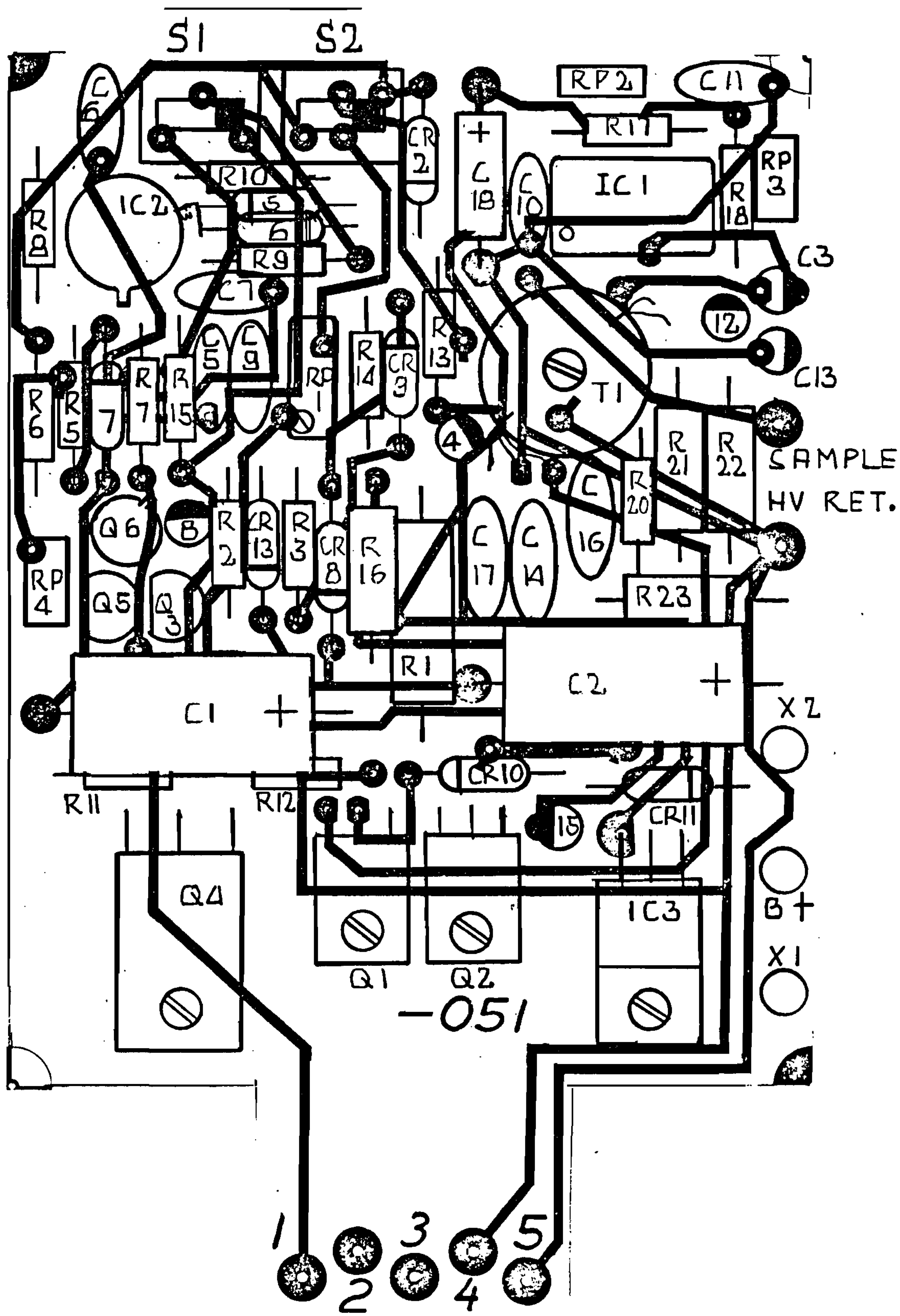
10. Unit should be fused with 1.5 A, slo-blo, except the -19 units, which need a 3 A fuse. The purpose of the fuse is to protect external wiring and <u>other</u> equipment.

11. Unit is shielded and the connections contain some RFI decoupling. If RFI is a problem, choke/capacitor filters should be installed at the input and output connections. The unit's switching frequency is also adjustable with trimpot RP 2. A synch pulse can also be introduced at pin 5 of IC 1, now bypassed, to keep the oscillator locked to an external clock.



S/D DRM/DUM SERIES

JJR 5-10-77


S1
S2
C6
R8
IC2
R10
5
6
R9
C7
C5
C9
RP 1
R14
CR3
R13
CR2
C18
C10
IC1
RP2
R17
C11
R18
RP3
C3
12
C13
T1
4
C16
R20
R21
R22
SAMPLE
HV RET.
R6
R5
7
R7
R15
Q6
8
R2
CR13
R3
CR8
R16
C17
C14
R23
RP4
Q5
Q3
C1
R1
C2
X2
R11
R12
CR10
15
CR11
Q4
Q1
Q2
IC3
B+
X1
-051
1
2
3
4
5

PARTSLIST DRM/DUM BOARDS (-050 &-051)

Item	Qty	Description	Part Number	Manufacturer	Ref #
1	2	Cap. Elyt, 100/40		Siemens	C1, 2
2	6	Cap. Tant 1/35	T368 A105M035 AS	Kemet	C3,4,8, C12,13,15
3	7	Cap. Ceram. .01/100		AE	C5,6,7,9 C11,14,17
4	1	Cap. Mica .001/200		CD	C10
5	1	Cap. Ceram. .0022/100		AE	C16
6	1	Cap. Elyt. 22/16		Siemens	C18
7	1	Zener, Ref.	1N825A	Transitron	CR2
8	5	Diode, signal	1N914		CR5,6,7,8,
9	2	Rectifier	1N4003	Mot	CR10, 11
10	1	Zener, 10V, 400mW	1N5240	Mot	CR13
11	1	Oscillator IC	NE555V	Signetics	IC1
12	1	Op-Amp	741 HC	Fairchild	IC2
13	1	Regulator	78M15UC	Fairchild	IC3
14	2	Transistor, Power	2N5192	Mot	Q1,2
15	2	Transistor, signal	2N4002	Mot	Q3, 5
16	1	Transistor, power	MJE 3055	Mot	Q4
17	1	Transistor, signal	2N2222	Mot	Q6

18	1	Trimpot, 10K	Piher	RP1
19	1	Trimpot, 100K	Piher	RP2
20	1	Trimpot, 2 K	Piher	RP3
21	1	Trimpot, 50K	Piher	RP4
22	1	Resistor, WW .47 ohm, 10% BWH	Ohmite	R1
23	1	Resistor CC, 2.2 K, 1/4 W,10%	AB	R2
24	2	Resistor CC 22 ohm. 1/4W, 10%	AB	R3,16
25	2	Resistor CC 1 K, 1/4 W, 10%	AB	R5, 20
26	1	Resistor MF, 483 ohm, 1% MK-2		R6
27	2	Resistor, CC, 100 ohm, 1/4W, 10%	AB	R7,8
28	3	Resistor, CC, 10K, 1/4W, 10%	AB	R9,10,17
29	1	Resistor, CC, 18K, 1/4W, 10%	AB	R11
30	1	Resistor, CC, 6.2K, 1/4W, 10%	AB	R12
31	1	Resistor, MF, 1.31 K, 1%, RN55C	Mepco	R13
32	1	Resistor, MF, 13.7K, 1%, RN55C	Mepco	R14
33	1	Resistor, CC, 82K, 1/4W, 10%	AB	R15
34	1	Resistor, CC, 270 ohm, 1/4W, 10%	AB	R18
35	2	Resistor, CC, 1K, 1/2W, 10%	AB	R21,22
36	1	Resistor, CC, 330 ohm, 1/2W, 10% SIT	AB	R23

37	1	Transformer bobbin 120:20:20		AHV	T1
38	2	Core-halves, transformer 1408 UG41408F		Mag Inc	T1
39	2	Switch, DPDT			S1
40	1	Heatsink	4800-000-017	AHV	
41	1	P.C. Board, complt.	-050/051	AHV	
42	1	Insulator, heatsink	-071	AHV	
43	1	Insulating washer, transformer	-072	AHV	
44	2	Insulator, Mica	B08853A001	MOT	
45	2	Insulator, Mica		MOT	
46	2	Insulator, Nylon	B51547F015	MOT	
47	4	Screw, 4-40X5/8 BH			
48	1	Screw, 4-40X1/2 BH			
49	5	Nut, 4-40, sml pattern			
50	1	Washer, flat, #4, sml pattern			
51	1	Washer, flat, #4, regular			
52	2	Washer, compression, #4	B52200F003	MOT	
53	2	Washer, compression, #6		MOT	

APPENDIX D

INSTRUCTION MANUAL FOR HIGH VOLTAGE POWER SUPPLY

SPELLMAN
HIGH VOLTAGE ELECTRONICS CORPORATION
7 FAIRCHILD AVENUE, PLAINVIEW, NEW YORK 11803 • 516-349-8686

INSTRUCTION

MANUAL

MODEL RHR 30N120/F9/220/IC
High Voltage Power Supply
SERIAL NO.: SP C-2877
DATE PRODUCED: 6/83

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL. EXTREME CAUTION MUST BE EXERCISED WHEN WORKING WITH THIS EQUIPMENT.

Correspondence and ordering Spare Parts

1. Each Spellman Power Supply has an identification label on the rear of the chassis (or on one surface of the housing, in modular supplies) that bears its model and serial number.

2. When requesting engineering or applications information, reference should be made to this model and serial number, as well as to the component symbol number(s) shown on the applicable schematic diagram, if specific components or circuit sections are involved in the inquiry.

3. When ordering spare parts, the information described in paragraph 2 should be given in addition to the 6 digit Spellman part number that appears on the schematic.

Examples:

1. When requesting engineering data:

   "...voltage across Capacitor C2, for serial No. S6584 of Model RHR30P60 power supply."

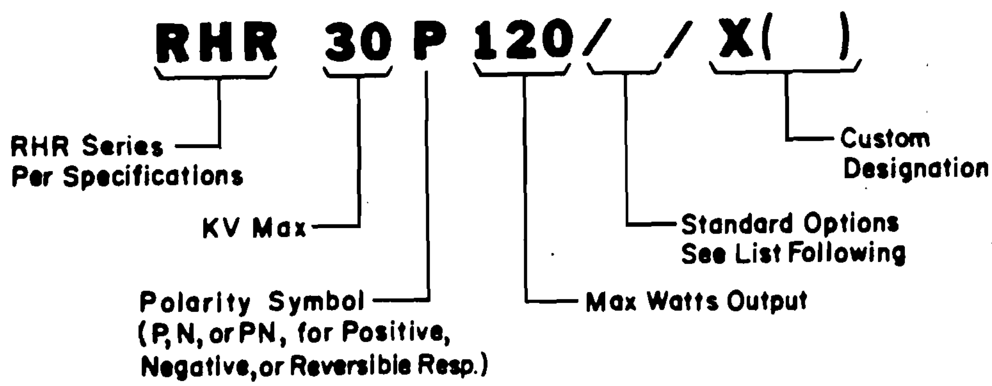
2. When ordering that component:

   "... one (1) Spellman Part No: 105423-1, Capacitor C2 for Serial No. S6584 of Model RHR30P60 power supply."

CONTENTS

I.1 GENERAL

The Spellman RHR line high-voltage power supplies described herein provide continuously adjustable, well-regulated high-voltage DC for use in the industrial, aerospace, computer, research, and instrumentation fields. The units feature 0.01% regulation, 0.02% ripple, and are available with a choice of positive, negative or reversible high voltage output polarity. Numerous configurations and options are available; the model-number explanation below covers the standard variations, as well as custom modifications.



I.2 RHR LINE OPTIONS

The RHR line is available with any combination of the options listed below. The appropriate code letters are suffixed to the model number, which is given on the title page as well as the name plate on the unit for this specific power supply.

CURRENT LIMITING	(CL)
OVERLOAD TRIP-OUT	(OL)
REMOTE VOLTAGE PROGRAMMING	(RVC)
BENCH CABINET	(C)
CURRENT REGULATION	(CR)
220 VOLT INPUT (50-60 Hz)	(220)
100 VOLT INPUT (50-60 Hz)	(100)
FOCUS TAP	(F)
BCD DIGITAL REMOTE PROGRAMMING	(BCD)
REMOTE RESISTANCE PROGRAMMING	(RC)
REMOTE MONITOR TERMINALS	(TP)
REMOTE CONTROL PANEL	(RCP)
PARALLEL OPERATION	(PM)
SLAVED BIPOLAR ($\pm$) OPERATION	(BPM)
FLOATING GROUND	(FG)

CURRENT LIMITING (CL)

DESCRIPTION:

This option automatically limits the load current to approximately 110% of rated load regardless of the overload imposed upon the power supply. The power supply continues to operate at any overload condition including a short circuit by automatically reducing the output voltage as required to maintain the current limit. The unit is self-restoring to its normal operating level when the overload condition is removed. The voltage cut-off characteristic is quite sharp and approaches the ideal characteristic of a voltage-current regulator with automatic crossover.

The CURRENT LIMITING option is supplied as standard on all models. No suffix letters are required in the model number.

APPLICATION NOTES:

The CURRENT LIMITING option should be selected when the load is erratic and can exceed the power supply rating frequently. In such situations, the reset requirement of the OVERLOAD TRIP-OUT option, described below, can be an annoyance. A typical example of this situation is a CRT which experiences occasional arc-overs. When the arc occurs, the CURRENT LIMITING circuit forces the output voltage to drop rapidly (depending on the load impedance). This helps the arc to extinguish and permits the power supply to regain its normal operating level.

continued . . .

CURRENT LIMITING is also desirable for capacitive load conditions. Frequently referred to as a "capacitor charger" type application, the CURRENT LIMITING option provides essentially a constant current charge. The standard OVERLOAD TRIP-OUT option, on the other hand, would cut-off in most cases due to excessive initial inrush current.

SPECIFICATION INFORMATION:

The CURRENT LIMITING option is provided as standard on all RHR models. Suffix letters are not required in the model number. Note that when the OVERLOAD TRIPOUT(OL) option is provided, it replaces the standard CURRENT LIMITING option. If a current limit level less than the power supply rated current is desired, this limit, in milliamperes is specified in parenthesis following the CL; i.e. CL(4) = 4 milliampere limit. NOTE: Values as low as 0.25 milliampere may be selected as standard.

OVERLOAD TRIPOUT (OL)

DESCRIPTION:

The OVERLOAD TRIPOUT protection feature rapidly "crowbars" the power supply when the load current exceeds approximately 110% of the rated load. A fast acting, latching circuit, removes power to the oscillator, thereby turning off the high voltage. The power supply must be reset by OFF-ON activation of the main AC power switch.

When the OVERLOAD TRIPOUT (OL) option is provided, it replaces the normally standard CURRENT LIMITING feature. See CURRENT LIMITING section above for additional information.

APPLICATION NOTE:

This protection arrangement provides the utmost in safety for personnel, load, and power supply. The trip-out is extremely sensitive and rapid, and will turn off the supply even for short-duration arcs in the load. This option should be selected in any situation where the inconvenience of having to "reset" the supply when occasional load arc-overs occur is acceptable.

SPECIFICATION INFORMATION:

Suffix letters (OL) appear at the end of the basic model number when this option has been provided.

If an overload trip-out level less than the power supply rated current is desired, this limit, in milliamperes, is specified in parenthesis following OL; i.e. OL(4) = 4 milliamperes trip-out. NOTE: Values as low as 0.25 milliampere may be selected as standard.

continued . . . . .

REMOTE VOLTAGE PROGRAMMING (RVC)

DESCRIPTION:

This option enables the power supply to be controlled by an external low voltage DC source. The output voltage is directly proportional to the input voltage with linearity and proportionality of 1% of full scale. The programming voltage polarity is always positive, regardless of the output polarity of the power supply.

The physical arrangement of this option is that a barrier type terminal board is provided on the rear of the chassis. Schematic information covering this option is provided at the back of this instruction manual and details the necessary interconnection wiring changes to permit normal operation using the front panel control, or disabling this control to allow for application of the programming voltage. Note that the programming voltage polarity should always be positive, regardless of power supply output voltage polarity. Shielded cable should be used for the programming voltage to prevent pick-up.

SPECIFICATION INFORMATION:

Suffix letters RVC appear at the end of the basic model number when this option has been provided.

Unless otherwise specified, the ratio of input to output is such that 0 to +6VDC controls the output from 0 to rated kilovolts. If a control voltage other than 6 volts is desired, any value desired between 10 and 250 volts DC may be specified in parenthesis after the option letters; i.e. RVC(10) specifies a 0 to 10 volt programming signal.

BENCH CABINET (C)

DESCRIPTION:

A deluxe styled rack cabinet is available for all models. The base dimensions are 22" wide x 18" deep. Height is selected to fit individual unit height. Two-tone blue-gray color scheme is standard. Carrying handles are located conveniently on the sides of the cabinet for easy handling.

SPECIFICATION INFORMATION:

Suffix letter (C) appears at the end of the basic model number when this option has been provided.

continued . . . . .

I.2 RHR LINE OPTIONS (continued)

CURRENT REGULATION (CR)

DESCRIPTION:

OUTPUT CURRENT AND VOLTAGE:	Same as corresponding standard RHR model. Output current is adjustable from zero to rated current over the full voltage compliance range from zero to rated voltage. A front panel mounted 10-turn potentiometer provides resolution of 250 ppm for the current control.
CURRENT REGULATION:	±0.1% for any current setting between 25% and 100% of rated value for a load variation from 10% to 100% of full voltage compliance.
PROTECTION:	The power supply output voltage is limited to a maximum of 110% of rated voltage in the event of an open circuited load.
RIPPLE:	0.1% RMS of output voltage

Other characteristics are similar to standard RHR voltage regulation specifications.

APPLICATION NOTE:

This type of unit is particularly suitable for gas laser excitation since the supply can provide a relatively high open circuit voltage for starting the plasma discharge. Once the arc has formed, the supply automatically operates in a constant current mode at any preset level.

SPECIFICATION INFORMATION:

Suffix letters (CR) appear at the end of the basic model number when this option is provided.

continued . . . . .

220 VOLT INPUT (50-60 Hz) (220)

DESCRIPTION:

Nominal input voltage between 220 and 250 volts RMS, 50-60 Hz, single phase can be accommodated with this option. Input current is approximately 1.0, 1.5 and 2 amperes RMS for 30, 60 and 120 watt models respectively.

SPECIFICATION INFORMATION:

Suffix (220) appears at the end of basic model number when this option is provided.

100 VOLT INPUT (50-60 Hz) (100)

DESCRIPTION:

Nominal input voltage between 100 and 130 volts RMS, 50-60 Hz, single phase can be accommodated with this option. Input current is approximately 1.5, 3 and 5 amperes RMS for 30, 60 and 120 watt models respectively.

SPECIFICATION INFORMATION:

Suffix (100) appears at the end of basic model number when this option is provided.

FOCUS TAP (F)

DESCRIPTION:

This option provides for a separate, supplementary output. The auxiliary voltage is obtained by including a DC to DC supply selected from the Spellman RM line of modules. Any 1.5 watt unit with voltage rating to 24KVDC may be selected. Specifications for this supplementary output are in accordance with RM line data.

Voltage control is provided on the front panel by means of a single turn potentiometer. If the RC, Remote Control, option is ordered for the main output, then provision is made for remote control of the auxiliary output also.

SPECIFICATION INFORMATION:

Suffix letter F(max KV) appears at the end of the basic model number when this option is provided. The number in the parenthesis is the rated maximum output voltage of the RM module. The polarity of the module is POSITIVE unless otherwise

continued . . . . .

FOCUS TAP (F)

specified.

EXAMPLE: RHR30P120F(6). This model number indicates that module RM6P1500D (4-6KV at 250 microamperes) is included within standard Model RHR30P120.

BCD DIGITAL REMOTE PROGRAMMING (BCD)

DESCRIPTION:

This option is supplied in the form of a separate programmer adaptor with all necessary connectors and cables for interconnection to the basic high voltage power supply. The programmer module is designed for rack mounting in standard 19" wide cabinetry. It is 3-1/2" high and 6-1/2" deep and may be mounted either above or below the basic power supply, or at any convenient remote location.

SPECIFICATIONS:

All standard RHR characteristics for regulation, ripple, etc. are not affected by the addition of the programmer module.

OUTPUT VOLTAGE: Digitally programmable by contact closures at a rear mounted terminal board on the programmer module. Four decades using BCD, 1-2-4-8 code are provided. Contact closures are made to the 16 terminal positions of BCD coding (with respect to common) in any desired combination. The output voltage is then the sum of all the selected terminals. Increments are based on the particular voltage rating of the supply. For 10KV models, the decades cover 1,2,4,8/ 10,20,40,80/ 100,200,400,800/ 1000,2000,4000,8000 volts. For 5KV models, the same increments are available except that the 8000 volt position is deleted. For models above 10KV, the decades have a minimum increment of 10 volts. For example, a 30KV model would have selectable values of 10,20,40,80/ 100,200,400,800/ 1000,2000,4000,8000/ 10,000, 20,000 volts. Accuracy of output voltage is 0.25% of setting from 10% to 100% of rated voltage.

PROTECTION: Current limiting is provided on all units to permit operation on capacitive loading. The standard front panel 10-turn potentiometer functions as an over-voltage limiter selector when the BCD module is connected. When the module is disconnected, the basic supply reverts to standard control from the front panel.

continued . . . . .

BCD DIGITAL REMOTE PROGRAMMING (BCD)

APPLICATION NOTE:

This model has been used successfully in conjunction with a punch-card programmer. The punched holes correspond to the required output voltage.

SPECIFICATION INFORMATION:

Suffix (BCD) appears at the end of basic model number when this option is provided.

REMOTE RESISTANCE PROGRAMMING (RC)

DESCRIPTION:

This option permits the output voltage to be controlled by either an external potentiometer (3 terminals) or the front panel 10-turn control potentiometer. A barrier type terminal board is mounted on the rear of the chassis for connection to an external potentiometer. When wired in accordance with the appropriate schematic, the front panel control is switched out, and the remote potentiometer assumes control. A 5000 ohm potentiometer is required, although fixed resistor dividers of equivalent value may be used. A shielded, insulated cable with a twisted pair should be used, with the shield connected to common. Up to 100 feet of cable is permitted.

SPECIFICATION INFORMATION:

Suffix (RC) appears at the end of the basic model number when this option has been provided.

REMOTE MONITOR TERMINALS (TP)

DESCRIPTION:

BNC connectors are provided on the rear of the chassis for remote monitoring of voltage and current. The voltage monitor circuit provides a 1 volt signal corresponding to maximum rated voltage accurate to 1%. The current monitor circuit is taken across a 100 ohm resistor (100mV/mA)

SPECIFICATION INFORMATION:

Suffix letters (TP) appear at the end of the basic model number when this option has been provided.

continued . . . . .

REMOTE CONTROL PANEL (RCP)

DESCRIPTION:

Any standard model may be supplied with the control panel removed from the basic supply. Terminal boards are added to the basic supply on the rear of the chassis and to the control panel so that the two parts are readily interconnected. 15 feet of appropriately shielded interconnection cable is provided. The control panel contains an AC power switch, fuse, and pilot light, kilovoltmeter, milliammeter, and 10-turn control potentiometer.

SPECIFICATION INFORMATION:

Suffix letters (RCP) appear at the end of basic model number when this option has been provided. NOTE that all models with output voltage of 150KVDC or greater are supplied with the REMOTE CONTROL PANEL as standard.

PARALLEL OPERATION (PM)

DESCRIPTION:

Any model in the RHR line can be used as a "master" controller for parallel operation of up to three "slave" units of the same rating from either the RHR or UHR line. Whether the "slave" units are from the RHR or UHR units, the overall characteristics of the parallel system are governed by the specifications of the RHR "master" supply and are the same as standard specifications except for ripple which will deteriorate to the UHR levels. Current unbalance between units is less than 10% and no derating is required for total current capability of the parallel system.

Each power supply unit may be used independently, if desired, by simple rearrangement of terminal board connections.

SPECIFICATION INFORMATION:

Suffix (PM) appears after the standard model number for the "master supply". Suffix (PS) appears after the standard model number for the "slave" supplies. Up to three "slaves" can be controlled by one "master".

continued . . . . .

SLAVED BI-POLAR ($\pm$) OPERATION (BPM) and (BPS)

DESCRIPTION:

Any positive polarity model in the RHR line can be used as a "master" for "tracking" control of the negative polarity equivalent RHR model. Thus, one control provides adjustment of both supplies from zero to rated output voltage. The negative polarity output "tracks" the positive output within $\pm$1% from 10% to rated output voltage. All specifications for regulation, ripple, etc. are governed by individual unit characteristics.

SPECIFICATION INFORMATION:

Suffix (BPM) and (BPS) appear after standard model number for positive and negative polarity units respectively.

FLOATING GROUND (FG)

DESCRIPTION:

The FLOATING GROUND feature isolates the "low end" return of the power supply with respect to ground. Nominal insulation of at least 100 volts RMS is provided for the "floating" terminal. The terminal is also bypassed to chassis ground by a one megohm resistance, a 0.1mfd. capacitance, and a neon glow lamp whose breakdown voltage is nominally 85 volts (type NE2).

The purpose and application of the FLOATING GROUND option is to permit the user to "ground" or return" the low end of the power supply at a point within his system which will suppress undesirable ground loop currents.

In some instances, the user may desire to monitor the load current with accurate instrumentation. For this situation, the user can insert his own current monitoring circuitry between the "FLOATING GROUND" terminal and "system" ground. This may consist simply of an appropriate milliammeter or microammeter, or alternatively, a current sensing resistor which can be calibrated with a sensitive digital or differential voltmeter, as desired. It should be understood, however, that a low impedance return to ground must be provided by the user for proper operation of the power supply One thousand ohms or less is quite appropriate, and ten thousand ohms would be an acceptable value, if necessary. Check with our Engineering Department for further information.

SPECIFICATION INFORMATION:

Suffix (FG) after the standard model number indicates that the FLOATING GROUND option is provided.

continued . . . . .

I. 3 DESCRIPTION

Spellman RHR line of high voltage power supplies provide a continuously adjustable source of well-regulated DC voltage. The DC output voltage is continuously adjustable from near zero to its rated maximum by means of a 10-turn front panel OUTPUT VOLTAGE control. The supplies operate from a standard 115 Volt AC line, are regulated, blower cooled and have excellent ripple filtering. The rack mounted RHR can be provided in a cabinet ("C" Option) for bench use.

These power supplies employ a sophisticated, modern, solid-state RF high-voltage circuit to provide an optimum combination of electrical performance, reliability and economy. The AC input is rectified, filtered, and fed to a Class C RF oscillator circuit employing silicon power transistors. A feedback loop that controls the driver - and, hence, the amplitude of the output voltage - consists of a wideband RF amplifier with variable gain controlled by the output of a differential operational amplifier. The input signal to the operational amplifier is the difference between a stabilized, temperature-compensated, zener-diode reference voltage and an accurately determined sample of the DC output voltage. The output of the RF oscillator is rectified and filtered in a solid-state multiplier - a doubler, quadrupler, etc., depending on the output voltage rating.

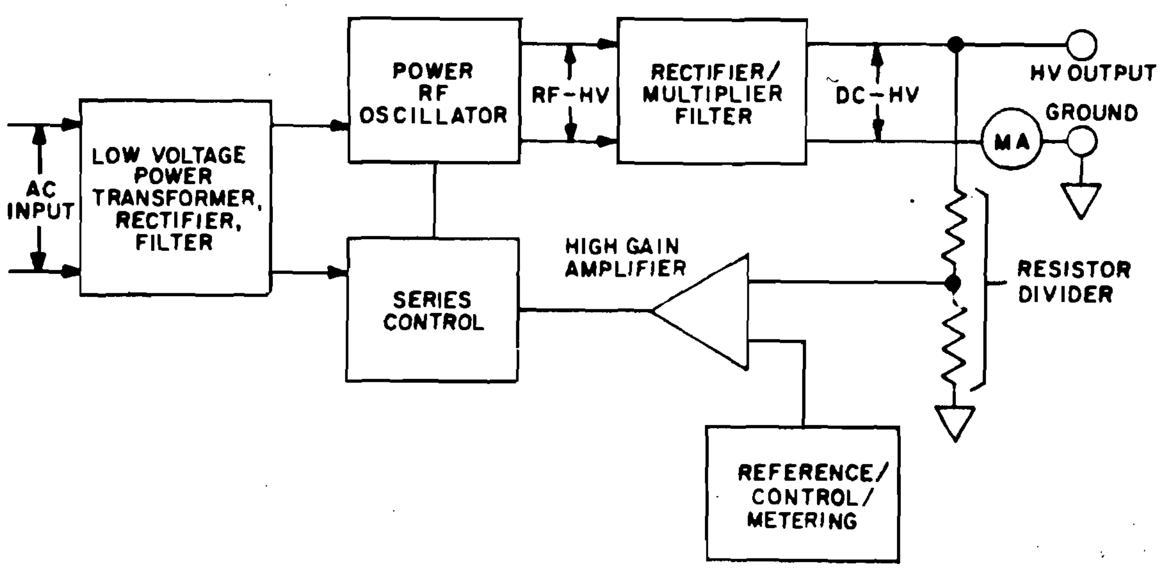
The RHR rack mounting models have front panels notched for mounting in a standard relay rack or cabinet. The "C" option models are RHR/s mounted in steel rack cabinets. The AC line power enters the power supply by means of a standard line cord, the line end of which is equipped with a 3-prong grounded plug.

On Models rated up to and including 100KV DC, the DC output is available at a high-voltage connector on the rear of the unit, and a matching output cable is provided. The DC output of models rated over 100KV is provided on a toroidal, anti-corona, high-voltage termination. A separate ground binding post is always provided, and should always be used.

The RHR line power supplies are furnished with either positive, negative, or reversible output polarity with respect to ground. A simple procedure is described in Section I.5 for reversing the output polarity on units with this feature ("PN" style).

continued . . . . .

If desired, the power supply may be interlocked by breaking one or both sides of the incoming AC line. AC transients resulting from interlock switching will not damage the equipment.



Simplified Block Diagram

I.4 UNPACKING AND INSPECTION

First inspect package exterior for evidence of rough handling in transit. If none, proceed to unpack ... CAREFULLY. After removing the supply from its shipping container, remove the top dust cover and inspect thoroughly for evidence of damage. (In cabinet models, remove the supply from its cabinet in order to inspect it.) Remove the jumper connections from the meter terminals. These are installed prior to shipment to "damp" the meters against vibrations which may occur in transit. If the units are reshipped at a later date, a similar process should be used.

IMPORTANT

In cases of damage due to rough handling in transit, notify the carrier immediately, if damage is evident from appearance of package.

Under any circumstances, do not destroy or remove any of the packing material used in a damaged shipment. Carrier companies will usually not accept claims for damaged material unless they can inspect the damaged item and its associated packing material. Claims must be made promptly - certainly within five days of receipt of shipment.

Check out the power supply as outlined as paragraph I.5 and fill out the Warranty Registration card accompanying the unit. Mail the Warranty Registration card promptly.

I.5 INSTALLATION AND OPERATION

After the equipment has been placed or mounted in position, the following procedure should be followed to connect and operate the equipment.

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL. EXTREME CAUTION MUST BE EXERCISED WHEN WORKING WITH THIS EQUIPMENT.

A 3-PRONG GROUND PLUG IS PROVIDED FOR CONNECTION TO AC LINE. IF A GROUNDED RECEPTACLE IS NOT AVAILABLE, USE AN ADAPTER AND CONNECT THE THIRD WIRE TO A GOOD GROUND - PREFERABLY A WATER SYSTEM GROUND.

ALWAYS MAKE CERTAIN THAT THE RETURN LINE FROM THE LOAD IS CONNECTED TO THE GROUND BINDING POST AT THE REAR OF THE UNIT. A GOOD EXTERNAL WATER SYSTEM GROUND SHOULD ALSO BE CONNECTED TO THIS BINDING POST.

A) For reversible polarity models (PN, in model number), open the top cover to set the output polarity as desired. In models up to 30KV DC, the high voltage assembly is fastened to the chassis in heavy duty retainer clips. For shipping purposes, the assembly is strapped to the clips by plastic cable ties. For fixed polarity models it is not necessary to remove the ties. For reversible polarity models, it is necessary to remove these ties to reverse the polarity.

   Operating polarity is identified by appropriate labels on the high voltage assembly. To change the polarity, unsnap the leads from the two ends of the assembly, lift the assembly out of the lower retainer clip, and finally pull it away from the upper clip. The assembly should now be free. Rotate it through 180° and replace the assembly in the retainer clips, reversing the above step-by-step procedure. Snap the high voltage leads back on to the assembly, and finally screw the cover back down on to the unit.

   For higher voltage models, the polarity reversal is effected by the interchange of leads in a plug/receptacle configuration - two plugs and two jack/receptacles are located at the high voltage assembly. The plugs are identified so that polarity is easily determined. Interchanging the plugs in the two jacks reverses the polarity.

B) Set the "POWER" switch to the OFF position.

C) Check the input voltage rating on the name-plate of the supply and make certain that this is the rating of the available power source.

D) Connect the high-voltage output cable and ground return lead to the load.

E) Connect the input cable to the power source.

continued . . . . .

F) If this supply has a focus output, connect the focus voltage cable from the load to the FOCUS output connector at the rear of the unit.

G) Rotate OUTPUT VOLTAGE control to fully counter-clockwise position. (This is optional, but desirable to prevent damage to external equipment caused by inadvertent overvoltage setting. Not required if correct setting has already been determined.)

H) Apply input power to the supply by setting POWER switch to ON (up) position.

I) Rotate OUTPUT VOLTAGE control clock-wise until voltmeter indicates desired output voltage (Monitor output current, to be sure maximum rating is not exceeded).

J. (For supplies with Focus outputs only.) Adjust FOCUS VOLTAGE control clock-wise, until desired focus voltage is obtained.

K) To shut down supply, set POWER switch to OFF (down) position.

WARNING! DO NOT HANDLE THE LOAD UNTIL IT HAS BEEN DISCHARGED CHECK KILOVOLTMETER!

(NOTE: FOCUS TAP IS NOT METERED IN STANDARD DESIGNS. USE EXTERNAL METER TO CHECK FOR SAFE CONDITIONS BEFORE HANDLING HIGH VOLTAGE WIRING!)

I.6 SPECIFICATIONS

INPUT: ______ to ______ volts, 50/60 Hertz, 1 phase. The full load input current is approximately ______ amperes at full load, 0.8 power factor.

OUTPUT - MAX. RATINGS Voltage and Current Ranges: 0 - ______ kilovolts DC at 0 - ______ milliamperes; Output polarity is ______ with respect to ground.

REGULATION -

STATIC LOAD: ±0.01% +1V, whichever is greater; NL to FL, at nominal line voltage.

STATIC LINE: ±0.01% +1V, whichever is greater; 105 to 125V input at fixed load within rating.

WORST CASE: ±0.02% +2V, whichever is greater; for any combination of above.

RIPPLE: 0.02% RMS +2V RMS whichever is greater. RMS = p-p/2.82

STABILITY: 0.02%/hour, 0.05%/8 hrs., at rated output voltage.

ENVIRONMENTAL DATA	OPERATING	STORAGE
Ambient Temperature:	-10 to +60°C	-25 to +71°C
Relative Humidity:	0 to 70%	0 to 90%

Temperature Stability: Maximum change in output voltage is 0.01%/°C at rated voltage from 0 to 60°C.

METERS: 3-1/2" rectangular; ±2% fs accuracy for current, ±3% fs combined meter and multiplier accuracy for voltage.

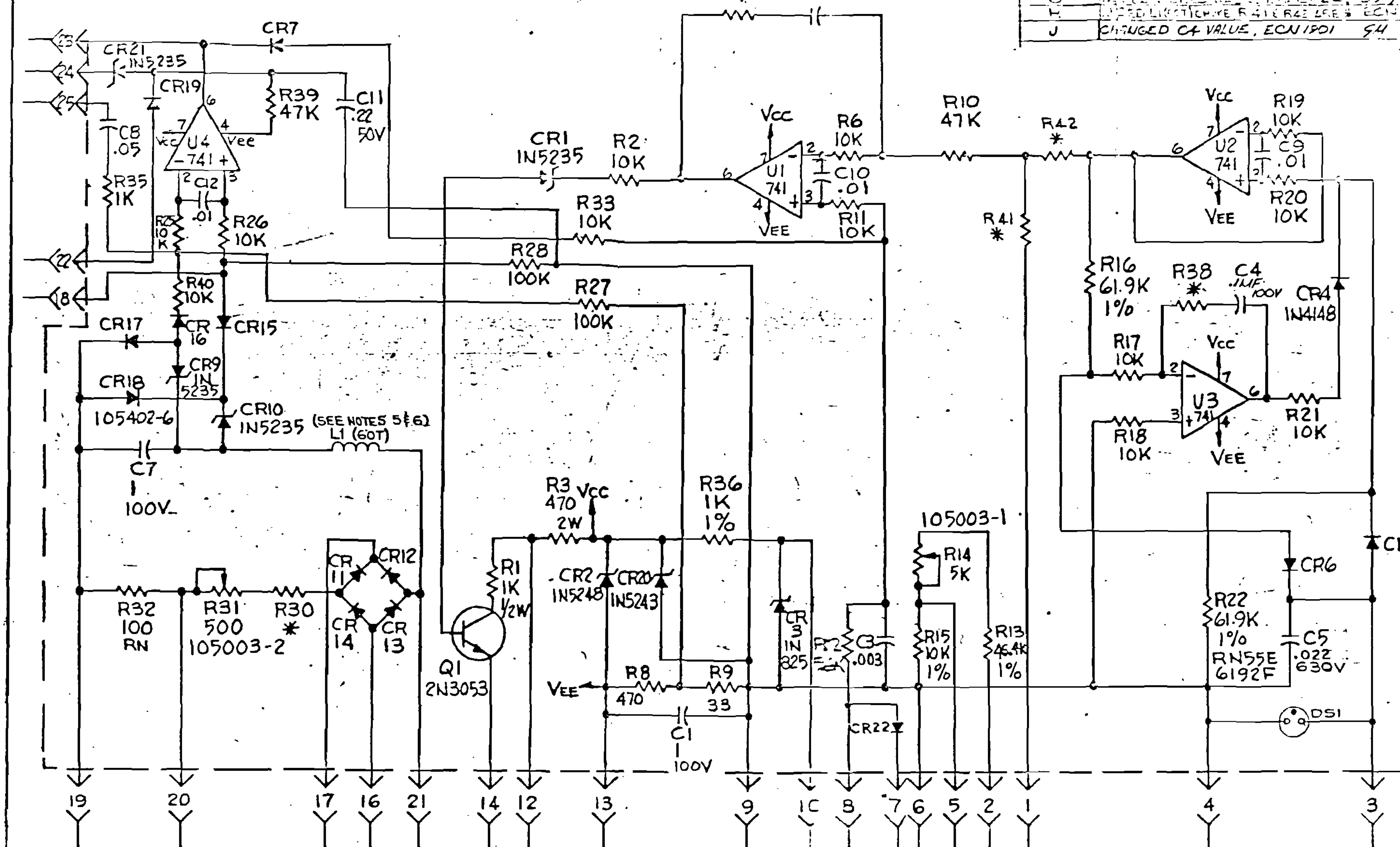
CONTROLS: AC power switch, fuse, pilot light, 10-turn high voltage control -0.02% resolution.

PROTECTION: Current limiting is provided as standard on all models. Refer to OPTIONS, Section I.2 for full description of the CURRENT LIMITING protection system, as well as other optional protection arrangements.

SIZE: 19" wide standard rack panel with standard notching 16-1/2" deep, ______" high.

WEIGHT: ______ lbs. net, ______ lbs. shipping

LTR	DESCRIPTION		
E	REVISED ISSUE FILED ... ADDED PIN TO CR22.		
F	R32 WAS 100Ω 1/4W, ECN 323		2-14-7?
G	[illegible]		
H	[illegible]		
J	CHANGED C4 VALUE, ECN 1901	94	11-9-8?



NOTES:
UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES ARE IN OHMS 1/4 W±10%.
2. CAPACITOR VALUES ARE IN MICROFARADS.
3. DIODES ARE TYPE IN4002.
4. * INDICATES FACTORY SELECTED COMPONENT.
5. ALL 6 DIGIT NUMBERS ARE SPELLMAN STANDARD PARTS AND ARE RECOMMENDED AS SPARE PARTS.
6. OVERLOAD (OL) - FOR OL OPTION: L1 IS USED, J2 PIN 23 IS CONNECTED TO J2 PIN 24, J2 PIN 18 IS CONNECTED TO J2 PIN 22.
7. CURRENT LIMIT (CL) - FOR CL OPTION: L1 MAY BE REPLACED BY JUMPER. REMOVE CONNECTION J2 PIN 23 TO J2 PIN 24 & J2 PIN 18 TO J2 PIN 22. J2 PIN 23 IS CONNECTED TO J2 PIN 25.

AMPL. ASSY	401081-100
TITLE	PART NO.
USED ON	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES

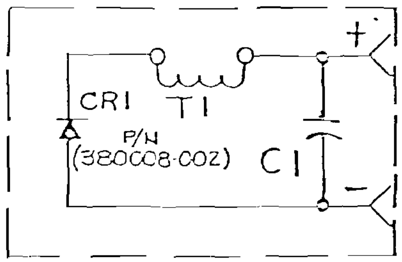
DRAFTSMAN | DATE 1/15/73
DESIGNER
CHECKED | 11/8/73
ENGINEER
APPROVED | 1/1/75
DO NOT SCALE DWG

TITLE
SCHEMATIC AMPLIFIER RHR / UHR

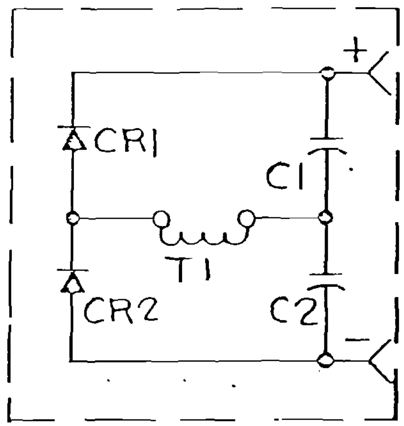
SPELLMAN HIGH VOLTAGE ELECTRONICS CORPORATION

SIZE C 301090-100
SCALE

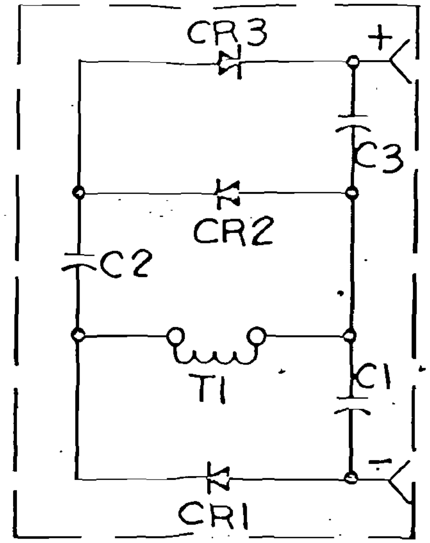
SYM	REVISIONS	DATE
A	T2B WAS T1 SEE ECN # 172	10/19/76
C	T1 WAS T2B, 20,25 & 30KV WAS 20 & 30KV, ADDED -001 ECN # 235	JB.
D	SEE ECN 332	3-1-77
E	SEE ECN. 493	12/5/77
F	SEE ECN 1452	12/1/80



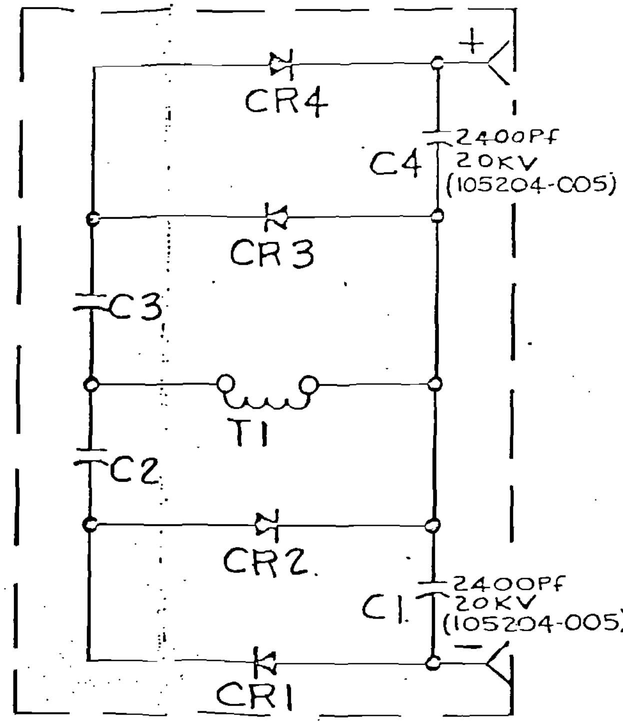
5KV(HALF WAVE)



10KV(DOUBLER)



15KV(TRIPLER)



20,25 & 30KV(QUADRUPLER)

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. T1 IS ELECTROMAGNETICALLY COUPLED TO T2. SEE MAIN ASSY SCHEMATIC.
2. ALL CR'S ARE 105402-008
   ALL C'S ARE 105204-023
   ALL T1 ARE 301590-006
3. ALL 6 DIGIT NUMBERS ARE SPELLMAN STANDARD PARTS AND ARE RECOMMENDED AS SPARE PARTS. FOR ADDITIONAL INFORMATION ON [illegible]

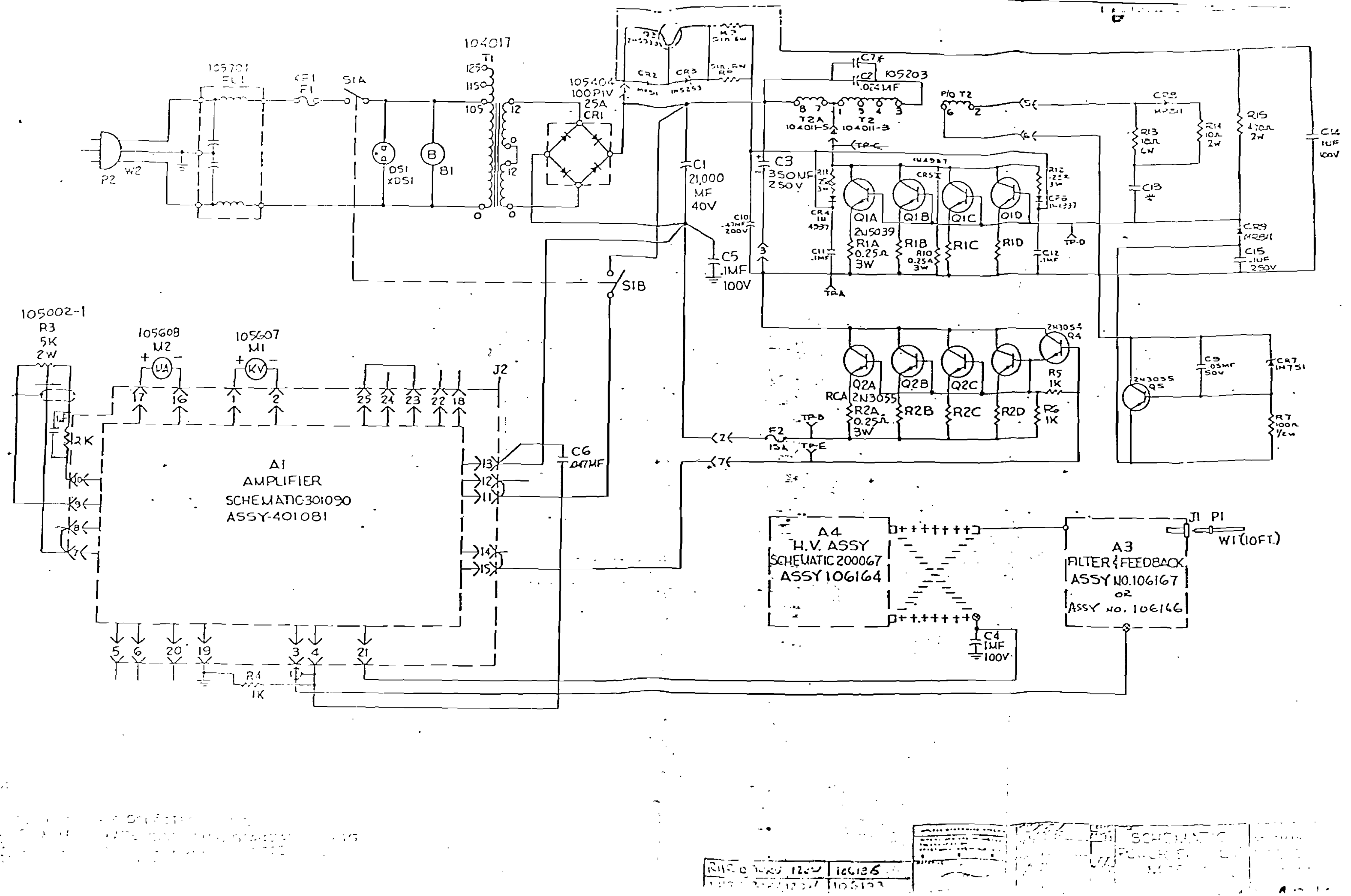
H.V. ASSY	401770-TAB
TITLE	NUMBER
USED ON	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± — DECIMALS ± — ANGLES ± —
MATERIAL —
PROTECTIVE FINISH —

		DATE
DRAFTSMAN	[redacted]	2 OCT 73
DESIGNER		
CHECKER		22/4/73
ENGINEER	[redacted]	3/01/77
APPROVED	[redacted]	1/73

TITLE
SCHEMATIC
HIGH VOLTAGE
ASSY

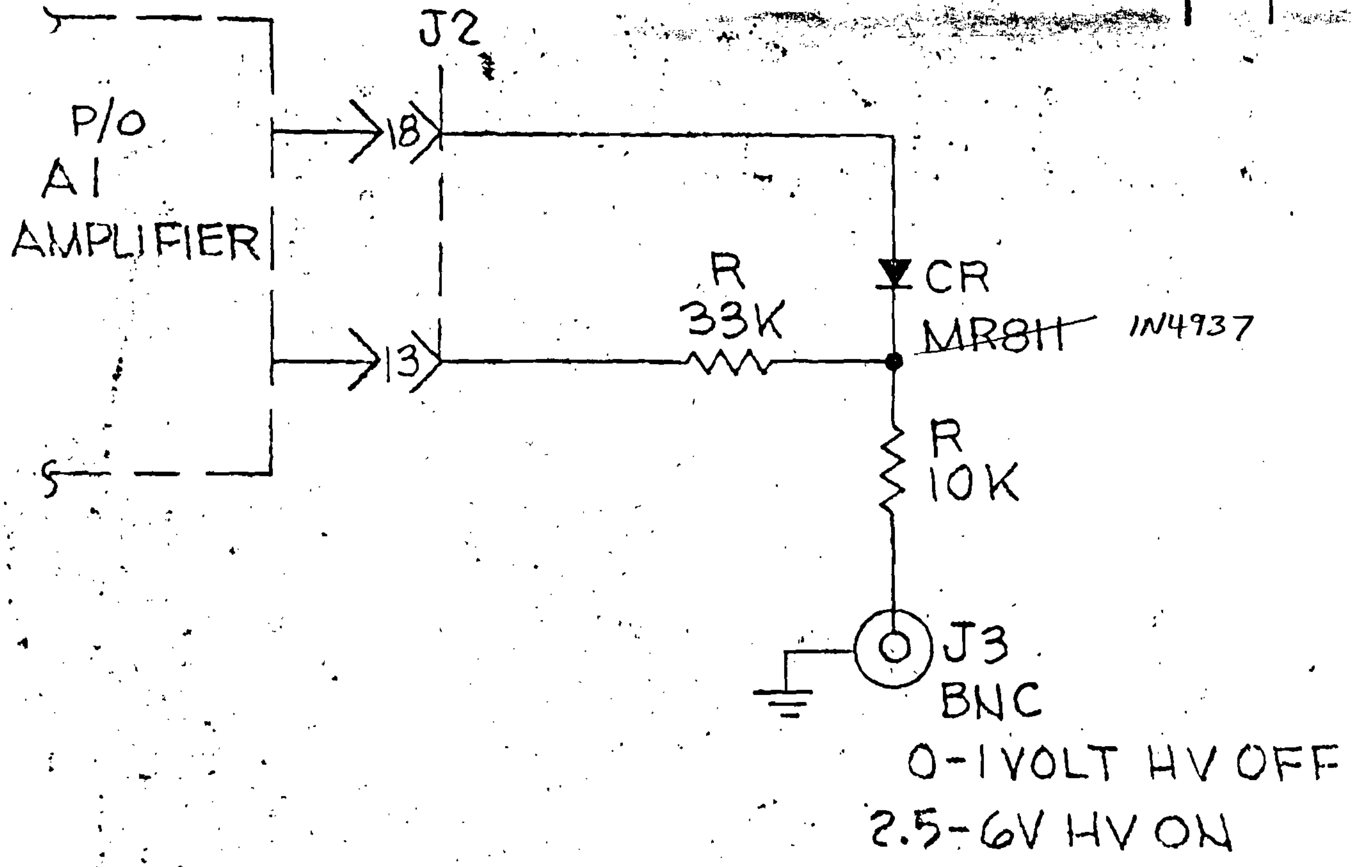
SPELLMAN
HIGH-VOLTAGE ELECTRONICS CORPORATION
7 FAIRCHILD AVE., PLAINVIEW, N.Y. 11803



105701
FL1
F1
S1A
104017
T1
105404
100PIV
25A
CR1
C1
21,000 MF
40V
C5
.1MF
100V
S1B
P2
W2
DS1
XDS1
B1
CR2
CR3
C7
C2
.024MF
105203
T2A
104011-5
T2
104011-3
P/O T2
C3
350MF
250V
Q1A
Q1B
Q1C
Q1D
2N5039
R1A
0.25Ω
3W
R1B
R1C
R1D
R10
0.25Ω
3W
TP-A
TP-C
TP-D
R12
R13
R14
R15
C13
C14
1UF
100V
CR9
C15
.1UF
250V
Q4
2N3054
Q2A
Q2B
Q2C
Q2D
RCA 2N3055
R2A
0.25Ω
3W
R2B
R2C
R2D
R5
1K
R6
1K
F2
15A
TP-B
TP-E
Q5
2N3055
C9
.05MF
50V
CR7
1N751
R7
100Ω
1/2W
105002-1
R3
5K
2W
105608
M2
105607
M1
J2
A1
AMPLIFIER
SCHEMATIC 301090
ASSY-401081
C6
.047MF
R4
1K
A4
H.V. ASSY
SCHEMATIC 200067
ASSY 106164
C4
1MF
100V
A3
FILTER & FEEDBACK
ASSY NO. 106167
OR
ASSY NO. 106166
J1
P1
W1 (10FT.)
106136

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL



M/F

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± DECIMALS ± ANGLES ±

MATERIAL —

PROTECTIVE FINISH —

DRAFTSMAN DATE 16 July 75

DESIGNER

CHECKER

ENGINEER [redacted]

APPROVED [redacted]

DO NOT SCALE DWG

TITLE

IC OPTION

SCALE — WT —

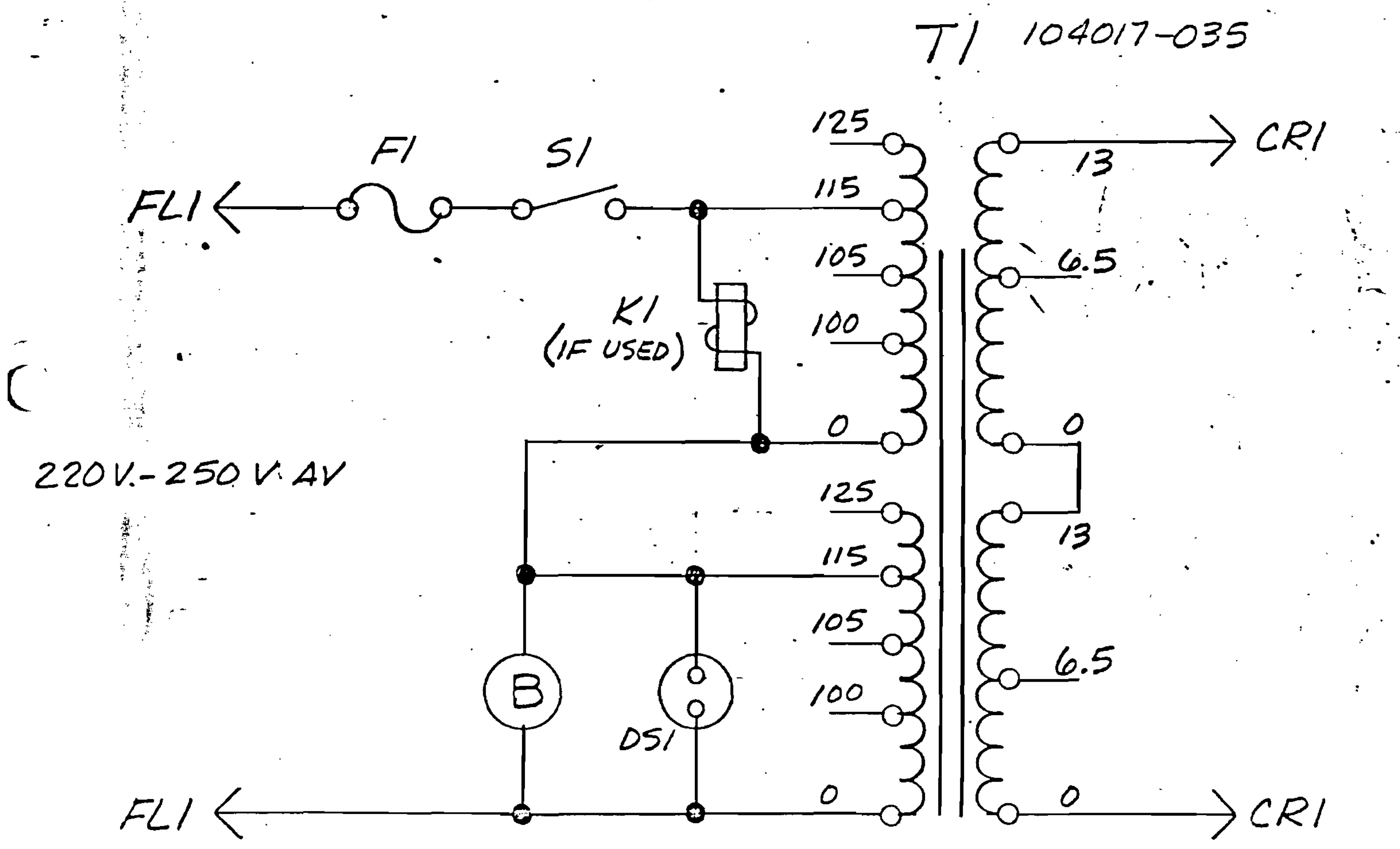
SPELLMAN
HIGH-VOLTAGE ELECTRONICS CORPORATION
1930 ADEE AVE , BRONX, N Y 10469

DWG SIZE A

100194

SH 1 OF 1

APPLICATION		REVISION			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
		B	REVISED & REDRAWN ECN 1270	5-15-80	M



M/F

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:	CONTRACT NO.	
FRACTIONS ± — DECIMALS .XX ± — .XXX ± — ANGLES ± —	APPROVALS	DATE
	DRAWN M. MAHONEY	5-15-80
MATERIAL —	CHECKED [redacted]	5/15/80
	DESIGN	
FINISH —	PROJ. ENG. [redacted]	5-15-80
DO NOT SCALE DRAWING	PROPRIETARY INFORMATION	

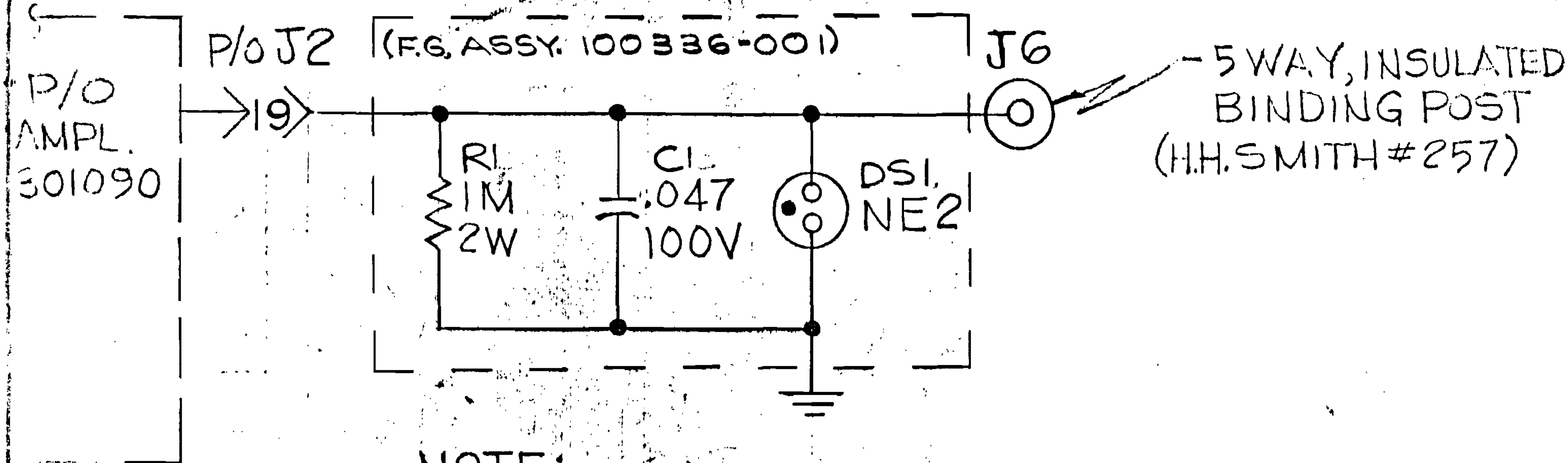
SPELLMAN
HIGH VOLTAGE ELECTRONICS CORPORATION
7 FAIRCHILD AVENUE, PLAINVIEW, NEW YORK 11803

220 V OPTION
RHR, UHR & RHSR

SIZE	CODE IDENT NO.	DRAWING NO.
A	IN788	100098-001

SCALE: —	PART CODE: 06	SHEET 1 OF 1

SYM	DESCRIPTION	DATE	APPROVAL
A	ADDED 1K RESISTOR	25 JUN 74	
B	TERM. #4. REMOVED FROM NOTE 1	12/10/75	
C	SEE ECN #415	10/29/80	



NOTE:
1. TERMINAL 19 REMOVED FROM GROUND.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± DECIMALS ± ANGLES ±	DRAFTSMAN	DATE 26 NOV 73	TITLE FLOATING GROUND OPTION (FG) MODEL RHR
	DESIGNER		
MATERIAL	CHECKER [redacted]	11/26/73	
	ENGINEER [redacted]	4/28/76	
PROTECTIVE FINISH	APPROVED [redacted]	4/28/76	
	DO NOT SCALE DWG.	SCALE	WT

SPELLMAN
HIGH-VOLTAGE ELECTRONICS CORPORATION
1930 ADEE AVE., BRONX, N.Y. 10469

DWG SIZE A | 100104-001 | SH 1 OF 1